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Review of New Source Performance Standards for Grain Elevators

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Review of New Source Performance Standards for Grain Elevators

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This report reviews the current Standards of Performance for New Stationary sources: Subpart DD - Grain Elevators. Emphasis is given to the state of control technology, extent to which plants have been able to meet current standards, experience of representatives of industry and of EPA officials involved with testing and compliance, economic costs, environmental and energy considerations, and trends in the grain elevator industry. Information used in this report is based on data available as of March 1983.

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Emission Standards and Engineering Division

U.S ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

January 1984

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1. EXECUTIVE SUMMARY

The new source performance standards (NSPS) for grain elevators were promulgated by the Environmental Protection Agency (EPA) on August 3, 1978. As specified in the Clean Air Act, the grain elevator NSPS applies only to grain terminal elevators with permanent grain storage capacity of 2.5 million bushels or greater, and grain storage elevators (mills) with permanent grain storage capacity of 1.0 million bushels or greater. These standards affect the truck loading station, truck unloading station, railcar loading station, railcar unloading station, ship loading station, ship unloading station, barge loading station, barge unloading station, grain dryer, grain handling operations, and emission control devices. Affected facilities are those facilities which commenced construction or modification after August 3, 1978.

The objective of this report is to review the NSPS for grain elevators and to assess the need for revision on the basis of developments that have occurred since the original NSPS was promulgated. The following paragraphs summarize the results and conclusions of the review, as well as recommendations with respect to EPA action in implementing any changes in the NSPS.

1.1 BEST DEMONSTRATED CONTROL TECHNOLOGY

The NSPS regulates particulate matter (PM) from the affected facilities named above. The original PM standard was based on the use of baghouses. No significant changes have occurred in control technology for the affected

particulate matter sources. Electrostatic precipitators (ESP's) cannot be used because of explosion hazards. Scrubbers are not used because of water and solid waste problems. Cyclones will not meet the NSPS.

Compliance test results, State and local control agency inspector reports, and unofficial observations during plant visits in this review show that all affected NSPS facilities are in compliance with the NSPS.

1.2 ECONOMIC CONSIDERATIONS AFFECTING THE NSPS

The capital and annualized costs for the control system for each affected facility were estimated during the NSPS development. During this review, those costs were updated to September 1982 dollars using the Chemical Engineer's plant cost index. In addition, costs for the affected facilities were revised based upon information supplied by industry and vendors.

The cost-effectiveness for each affected facility was estimated from the updated and revised costs and the emissions reduction resulting from the application of the control techniques. No credits were taken in these cost estimates for the recovered grain dust. The cost effectiveness of the various affected facilities ranges from about $90 for the grain dryer facility, to about $870 for the ship loading station.

Since the NSPS was promulgated, only six NSPS grain elevators have started operation or been modified. The growth rate for grain production has been about 14 percent per year between 1978-1981 but grain elevators have been designed to handle more grain rather than to build new facilities.

Since the Clean Air Act exemptions are based on storage capacity, facilities may significantly increase handling rate without being regulated by the NSPS. The forecast for growth is difficult to determine for the next few years because of what happens in the world markets, government policies, and excess supplies.

1.3 RECOMMENDATIONS OF REVISION OF CURRENT NSPS

There has been general compliance with the current NSPS, as reported by State and local agencies, and the achievability of the existing standard has been demonstrated. Based on information provided EPA during this review, it is recommended that the basis for the NSPS remain unchanged.

1.4 RECOMMENDATION ON EXTENSION TO THE NSPS

Because there are not any other types of pollutants being emitted for the grain elevator affected facilities, there will be no considerations for extension of the NSPS to other processes or pollutants.

2. INDUSTRY STATUS

2.1 Introduction

On August 3, 1978, the Environmental Protection Agency (EPA) promulgated new source performance standards (NSPS) for the grain elevator industry. As specified in the Clean Air Act, the grain elevator industry NSPS applies only to grain terminal elevators with permanent storage capacity of 2.5 million bushels or greater and grain storage elevators (mills) with permanent storage capacity of 1.0 million bushels or greater. These standards established emission limits and equipment specifications for and require testing and reporting of particulate emissions from the various grain elevator processes that were built or modified after August 3, 1978. The Clean Air Act Amendments of 1977 require that the EPA Administrator review and, if appropriate, revise such standards every 4 years [Section 111(b)(1)(B)].

This report represents the results of a review of the NSPS for the grain elevator industry. The report covers recent and projected growth of the grain elevator industry and describes any changes in process and control technology since NSPS promulgation.

The review was conducted by reviewing recent literature on grain elevator industry statistics, discussions with EPA Regional Offices and State and local air pollution agencies, discussions with process and emission control equipment vendors, visiting new or modified elevator facilities, and discussions with the National Grain and Feed Association.

2.2 The Grain Elevator Industry

The grain elevator industry has not changed significantly since the promulgation of NSPS in August 1978. There are fewer small country elevators

in favor of larger storage or higher handling capacity elevators. Also, because of sluggish or low farm prices, more grain is being stored on farms.[1] Commentators, during the development of the NSPS, provided data to estimate that about 200 elevators would come under NSPS regulation by 1982.[2] However, this review indicates that only six grain elevator facilities and no flour mills are required to meet the NSPS requirements. Industry sources indicated in their questionnaire responses that the grain elevator industry would be growing, but none could provide any definitive data on the industry's growth over the next 5 years. However, a large constructor of grain elevators estimated that for about 2 years the growth rate will be negligible until the grain glut is resolved, then growth would increase at about 5 percent per year.[4]

Grain elevator facilities are used to condition, handle, and store grain[1/] as it moves from the farm to markets. In general, elevators are classed as either "country" or "terminal." The U. S. Department of Agriculture (USDA) distinguishes between country and terminal elevators on the basis that terminals furnish official weights; that is, each receipt or shipment is weighed under the supervision of a State inspector; however, not all terminal elevators furnish official weights.

Country elevators generally receive grains as they are harvested in fields within 10 to 20 miles or more of the elevator. They unload, weigh, and store the grain and may dry or clean it before shipment to terminal elevators or processors. Terminal elevators are classified into two groups, inland (or

1/ Grain includes wheat, corn, oats, millet, soybeans, rice, milo, and other similar products.

subterminals) and port terminals. Inland terminal elevators receive most of their grain from country elevators and ship to processors, other terminals, and exporters. The primary functions of most inland terminal elevators are to store grain in quantity and condition it to meet buyer's specifications. They dry and clean grain, as country elevators do, but they also blend different grades of grain.1/

Port terminals are defined as those located on major waterways or in seaports which export agricultural products. The port terminal provides the same basis functions as an inland terminal, but can load ships and barges.

Plants, which process grain in-house, also use elevators to receive and store grain. These plants process grain into food or food intermediates for human and animal consumption. All of the same basic functions are performed at storage elevators owned by processors as at country or terminal elevators. Rarely is grain shipped by processors.

About 85 percent of the grain sold by farms is handled by country elevators before shipment to terminal elevators or grain processors. The other 15 percent bypasses country elevators. This is possible largely because improved roads, larger trucks, and more on-farm storage facilities make it economical to ship directly to more distant terminal elevators and processors. Figure 2-1 shows the flow of grains from the farm to market and the number of grain elevators in operation in 1981.

Agricultural Stabilization and Conservation Service (ASCS) data show that the average storage capacity of a country elevator is about 400-500,000

1/ The USDA classifies each grain into six grade. No. 1 grade grains must meet specific minimum test weights (pounds per bushel) and maximum limits on the percent moisture, foreign material, damage, etc.

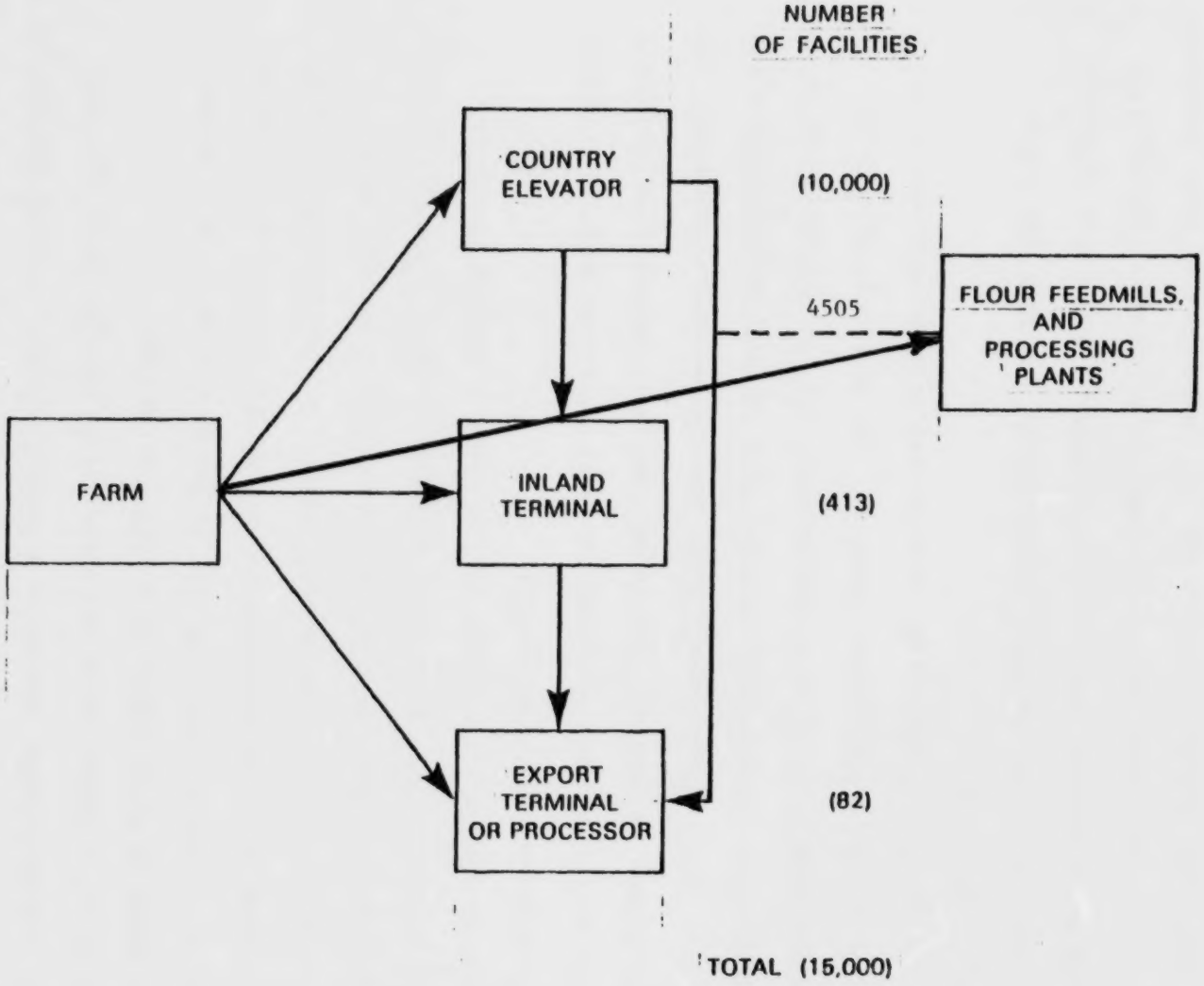


Figure 2-1. Grain Flow from Farm to Market.

bushels. Typical storage capacities of country elevators constructed today range from 300,000 to 1,000,000 bushels. Terminal elevators can have a storage capacity of zero to about 4,000,000 bushels or more. The storage capacity of grain elevators can be increased by adding bins on to the original structures and storage in steel tanks or warehouse-type buildings ("flat storage"). The largest capacity under one roof is 18,000,000 bushels. The storage capacities of processing plants range between 500,000 and 3 million bushels.[3]

Country elevators receive almost 100 percent of their grain by truck. They ship primarily by truck and rail in near equal quantities. Inland terminals receive grain primarily by truck and rail, and ship primarily by rail and water. Port terminals receive grain by rail, truck, or barge, depending on their location and facilities. They ship almost exclusively by water.

Although elevators are located throughout the United States, the major concentration is in the grain producing States in the Mid-Plains, South Plains, and Great Lakes regions. Terminal elevators are located in the principal grain-marketing and shipping centers, most of which are in metropolitan areas.

Grain processing facilities for wheat, corn, and rice mills, soybean processing plants, and wet corn mills are located in both rural and urban areas. Although most were originally constructed in rural areas, they have since been surrounded by metropolitan growth.

2.3 The Emission Problem

There are five primary functions that take place in an elevator as shown in Figure 2-2; receiving, handling, cleaning, drying, and shipping. All of

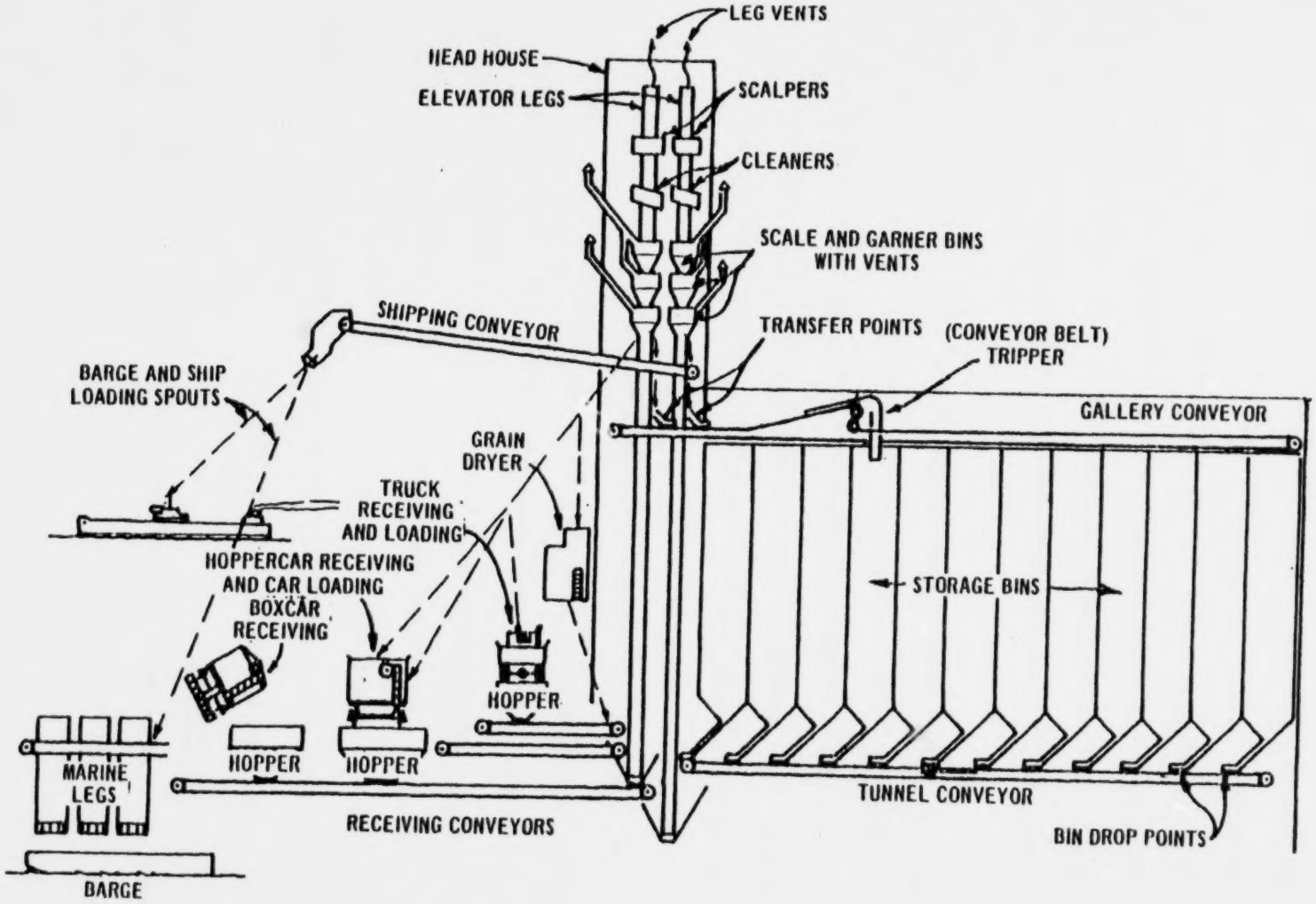


Figure 2-2. Terminal elevator.

these are materials handling processes rather than processes which effect a chemical or physical change in the product. Particulates are the main pollutants, although very small amounts of combustion products can be emitted from grain dryers (these usually operate less than 3 months per year and burn natural or propane gas). The dust (or particulates) may contain 60-90 percent organic material. Three to twenty percent of the inorganic portion may be free silicon (sand from entrained dirt). Specific materials in the dust include particles of grain kernels, spores of smuts and molds, insect debris, pollen, and dirt from the field.[3]

The grain dust can be emitted from almost any point in the elevator process and most of the emissions are fugitive. They become airborne in most cases because of ineffectual hooding or pollutant capture systems; even effective hood designs may allow some dust to escape.

2.4 Grain Elevator Handling Facilities

The grain handling facilities at an elevator include receiving (by truck, railcar, and barge), handling and conveying, cleaning, drying, and loading (into trucks, railcars, and marine vessels).

Several factors common to each of the grain handling facilities that can affect emissions are discussed below. The first is the characteristics of the dust which varies with the type of grain handled. A test conducted to determine the magnitude of emissions from several grain handling facilities also indicated that emissions from soybeans were higher than for corn, wheat, and milo at the time of the test.[3] Soybeans may contain more dirt since they grow close to the ground and the harvester may scrape up earth as it cuts the plant off. Corn as "beeswings," large flaky particles that readily become

airborne because of their large surface area and low density. They can be a nuisance to nearby residents during the harvest season. The moisture content of the grain is another factor. It can vary from 11 to over 35 percent at harvest, however, not enough data are available to quantify the effect on emissions.

The percentage of "foreign material" or "dockage" in grain (the ratio of the weight of material other than whole grain kernels to the total weight) can also affect emissions. Most of the foreign material may be weed seeds, broken kernels, dirt, stones, and other heavy particles that do not cause an emission problem. However, since chaff, straw, and other light materials are also present with the heavy particles, a high percentage of foreign matter is a rough indication of high emissions potential. The percent foreign matter is often determined for each load of grain received or shipped.

2.4.1 Truck Receiving

Grain is emptied from most trucks (see Figure 2-3) by lifting the front end with a hydraulic platform to allow grain to flow from the tailgate. The grain falls from the truck through a heavy grate and into the receiving hopper. Dust-laden air evolves as air in a hopper is displaced by grain. A conveyor beneath the hopper moves the grain to storage bins.

The size of the receiving hopper limits the speed at which the grain can be handled. Small hoppers used at country elevators and elevators at grain processors where grain can be received at a relatively slow pace minimize air pollution. By rapidly filling with grain, they "automatically" decrease the free-fall distance from the truck bed. When this "choke feed" principle occurs, it may take 5 to 10 minutes to empty a truck. At

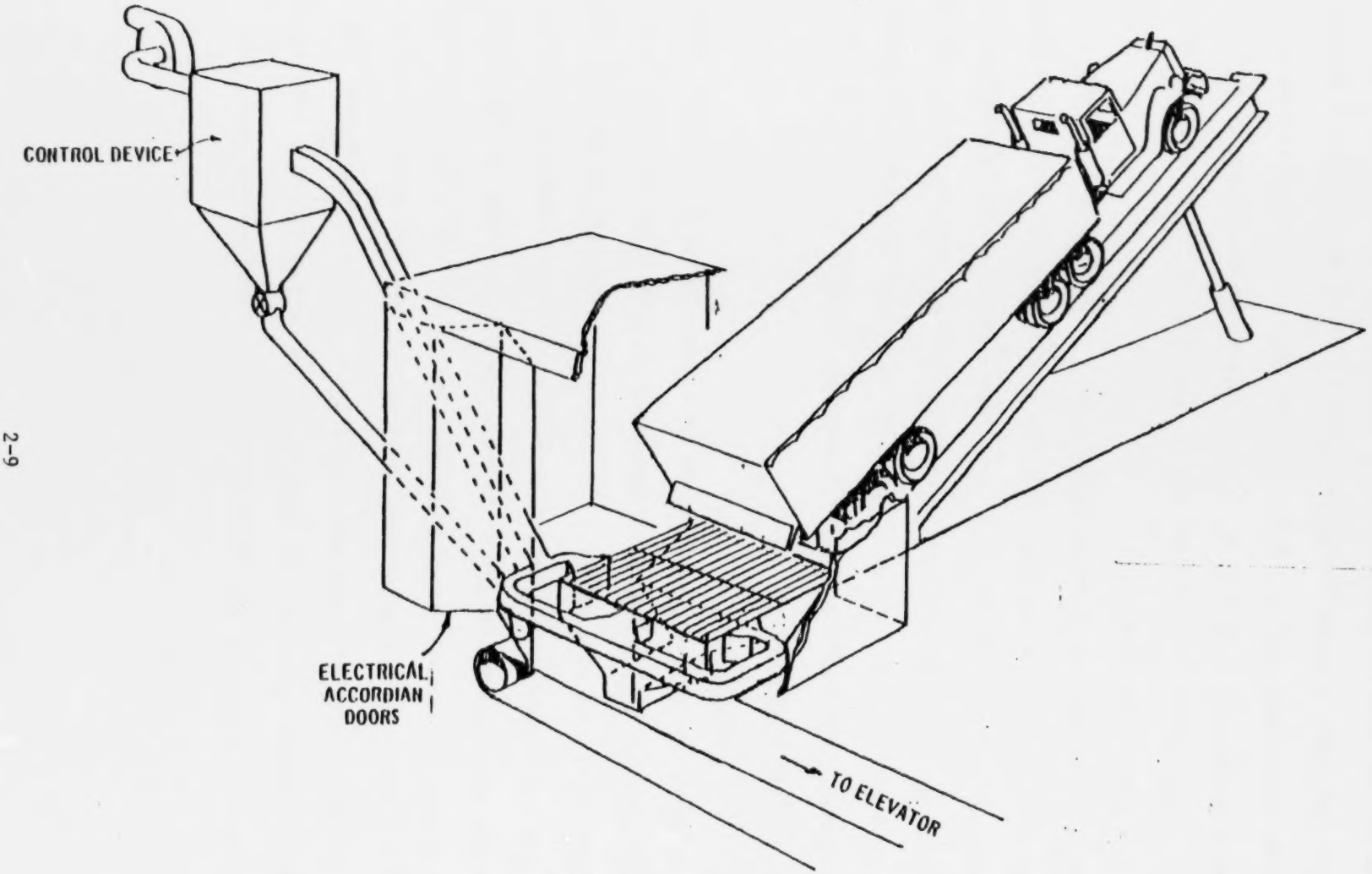


Figure 2.3. Truck unloading control system

subterminal and terminal elevators where large receiving hoppers and hydraulic platforms are used, a large 800 bushel truck is often emptied in 3-4 minutes.

Some trucks have trailers with "hoppers" from which grain is emptied through approximately a 24 inch by 24 inch opening in the bottom of each hopper. Comparatively little dust evolves when hopper trucks are unloaded since the grain flows slowly.

Most facilities, in order to protect the receiving hopper, have a shelter with a roof and two sides that trucks can drive through. Unfortunately, this type of building can act as a "wind tunnel" which not only increases dust emissions but make them more difficult to contain and capture. Newer facilities have quick closing doors at one end which close when the truck is in position to be dumped, thus reducing or eliminating the "tunnel" effect.[5,6,7,8,9,13]

2.4.2 Railcar Receiving

2.4.2.1 Hopper Cars

Hopper cars are typically divided into compartments or hoppers. Each has an opening about 2 feet square in the bottom through which the grain is discharged into a receiving hopper. The receiving hopper may be small so that only one compartment at a time can be emptied. This is common at country elevators and elevators at grain processors where grain can be received at a relatively slow pace. As at truck stations, small receiving hopper rapidly fill with grain thereby decreasing the free-fall distance from the hopper car and minimizing air emissions (see Figure 2-4). At larger facilities the receiving hopper can permit all hoppers on the railcar to empty simultaneously. Most facilities protect the receiving hopper from the weather by a large

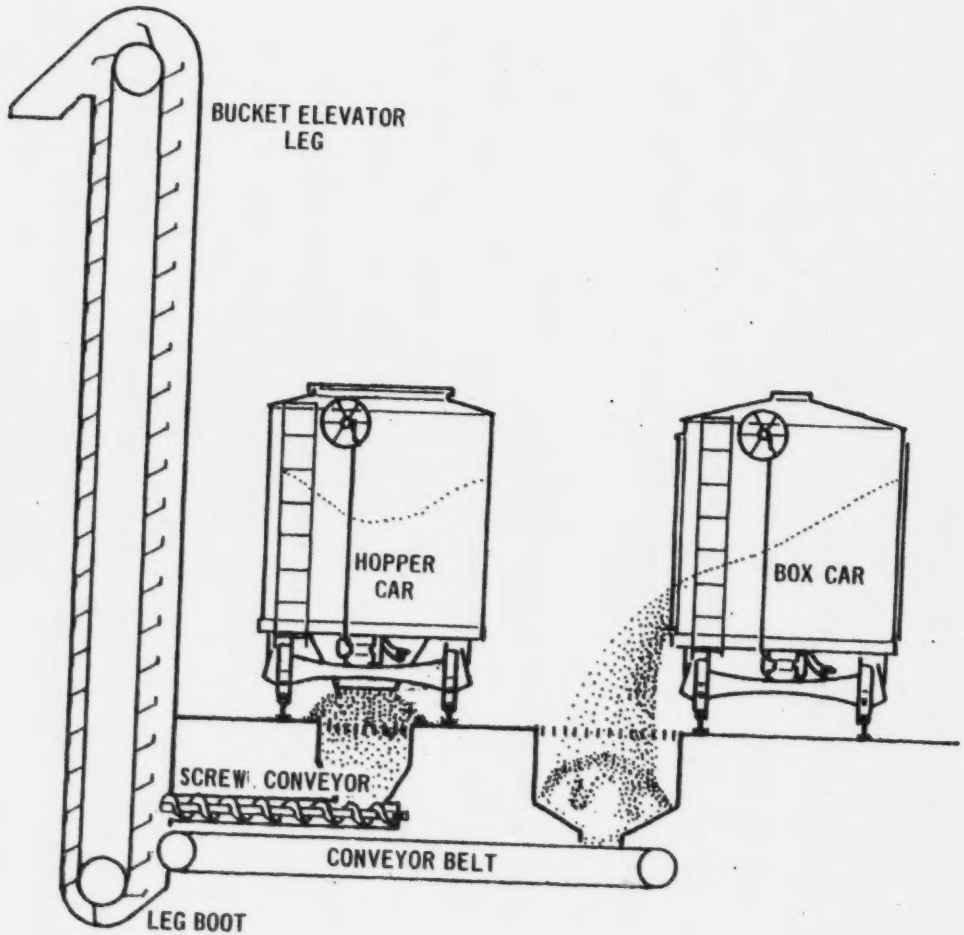


Figure 2-4. Rail car receiving.

shed with large openings at both ends. The shed can act as a wind tunnel which makes it more difficult to contain and capture dust emissions.[13]

2.4.2.2 Boxcars

Conventional boxcars are sometimes used to haul grain. Before it is loaded, a boxcar must be fitted with a "grain door" which is installed over the lower part of the sliding door openings in the side of the car. The grain door is made of wood or heavy cardboard and covers about three-fourths the height of the car door opening.

The most common method of unloading boxcars is to break the grain door. This results in a surge of dust as the grain falls into the receiving hopper beside the tracks (see Figure 2-4). After this initial surge, the remaining grain is scooped out of the car using power shovels, a front end loader, or some similar means. A cloud of dust forms as each scoop of grain strikes the receiving hopper. The other common unloading technique, used mainly by terminal elevators, is a mechanical car dump. The car is clamped to a movable section of track which rotates and tilts the car to dump the grain out of the door into the receiving hopper. This technique is rapid but results in violent agitation of the air around the flowing grain. These air currents entrain the grain dust and sweep it from the receiving area. During this review, it was found that the use of boxcars is rapidly declining and some terminals will not accept them. Modern large terminals like to unload unit trains (100 cars or more) rapidly and only hopper cars allow this rapid unloading rate.

2.4.3 Barges

Grain is received by barge at some inland terminals but mostly at port terminal elevators. The unloading areas are generally open to the weather. In most cases, grain is unloaded with a bucket elevator (marine leg) that is lowered into the barge.[12,7,5] Their capacities range from 15,000 to 75,000 bushels per hour; the average is about 30,000.

Dust is generated in the barge by the buckets of the leg and at the transfer point at the top of the leg where the grain is dumped into a receiving hopper. To completely clean the barge, it may be necessary to push or pull the grain to the leg with power shovels or front end loaders. These too, generate fugitive dust emissions. In the Northwest, specially designed barges are equipped with a screw conveyor that can bring the grain to the center of the barge and marine leg.[10,11] This allows the rest of the barge to remain closed and requires no additional equipment (front end loaders, etc.) to handle the grain. This process keeps emissions from barge unloading very low.

2.4.4 Grain Handling and Conveying Equipment

Handling and conveying equipment includes bucket elevators (legs) used to elevate the grain; conveyors (screw, drag, and belt type) which move it horizontally; scale and surge bins used to weigh it; and distributors which direct it to one of several places in the elevator complex.

A screw conveyor is a screw (6 inches or more in diameter) contained within a trough. The grain which enters one end of the trough is pushed forward as the screw turns. A drag conveyor consists of a continuous chain with paddles attached inside a rectangular enclosure. The grain is

pushed forward by the paddles. These conveyors move the grain slower (about 100-175 feet per minute) than belt conveyors. A belt conveyor is a continuous belt (about 24-72 inches wide) that carries the grain forward at about 300-800 feet per minute. Friction between the grain and the belt occurs only when it drops onto the moving belt, therefore, few kernels are broken.

The grain is usually conveyed to a leg which lifts it to the top of the "headhouse" where it is discharged to a distributor system (see Figure 2-4). The grain is usually distributed directly from the headhouse into storage bins or silos. Some newer facilities do not use legs and use conveyors to distribute the grain throughout the facility.

To ship grain, it is dropped from the bottom of the silo, conveyed to a leg, and elevated to the distributor or just conveyed to the distributor for those newer facilities without legs. From there it falls to grain cleaners or the load-out scales. Some country and terminal elevators have scales which are preceded and followed by surge bins. Conveyors discharge a continuous stream of grain into the upper surge bin while the scale weighs batch quantities and discharges them into the lower surge bin, which also empties continuously. The grain either drops directly into the shipping vehicle, or is conveyed to the shipping station.

Dust emissions may occur at transfer points as grain is fed onto or discharged from a conveyor. Examples of transfer points are the discharge from one conveyor onto another, the discharge from a leg onto a conveyor, or the discharge from a storage silo onto a tunnel belt conveyor. If these transfer points are open to the atmosphere, fugitive dust will be emitted

directly to the interior of the elevator. This can affect the working environment in the elevator and cause occupational health, housekeeping, and explosion propagation problems.

Dust emissions from handling equipment can be prevented in many areas through the use of totally enclosed equipment. Another method which minimizes dust is to handle grains at lower velocities. This reduces agitation of the air around the flowing grain and less dust becomes airborne.[14]

2.4.5 Grain Cleaning

Grain cleaners are used in many elevators because the grain must meet USDA standards (Figure 2-5). Equipment used to clean grain varies from scalping it to a simultaneous screening and winnowing operation. The simple screening devices remove large sticks, rocks, tools, and other trash. Screening operations are usually totally enclosed and emissions generated are captured and collected in a fabric filter.

2.4.6 Grain Drying

Depending upon the grain and its basic moisture content, some grains must be dried within a few days after receipt to prevent spoiling. Corn, soybeans, and milo are the three major grains that require drying. A typical country elevator might be equipped with a 1000-3000 bushel per hour (bu/hr) dryer while a typical terminal elevator may have one or more 3500-5000 bu/hr dryers. There are two basic types of grain dryers, rack and column (see Figures 2-6 and 2-7). Grain enters the top of both types and flows downward in a continuous stream and out the bottom. Heated air blown through the grain streams evaporates the excess moisture. Grain with 16-35 percent moisture can be reduced to 15-17 percent in one or more passes through the dryers.

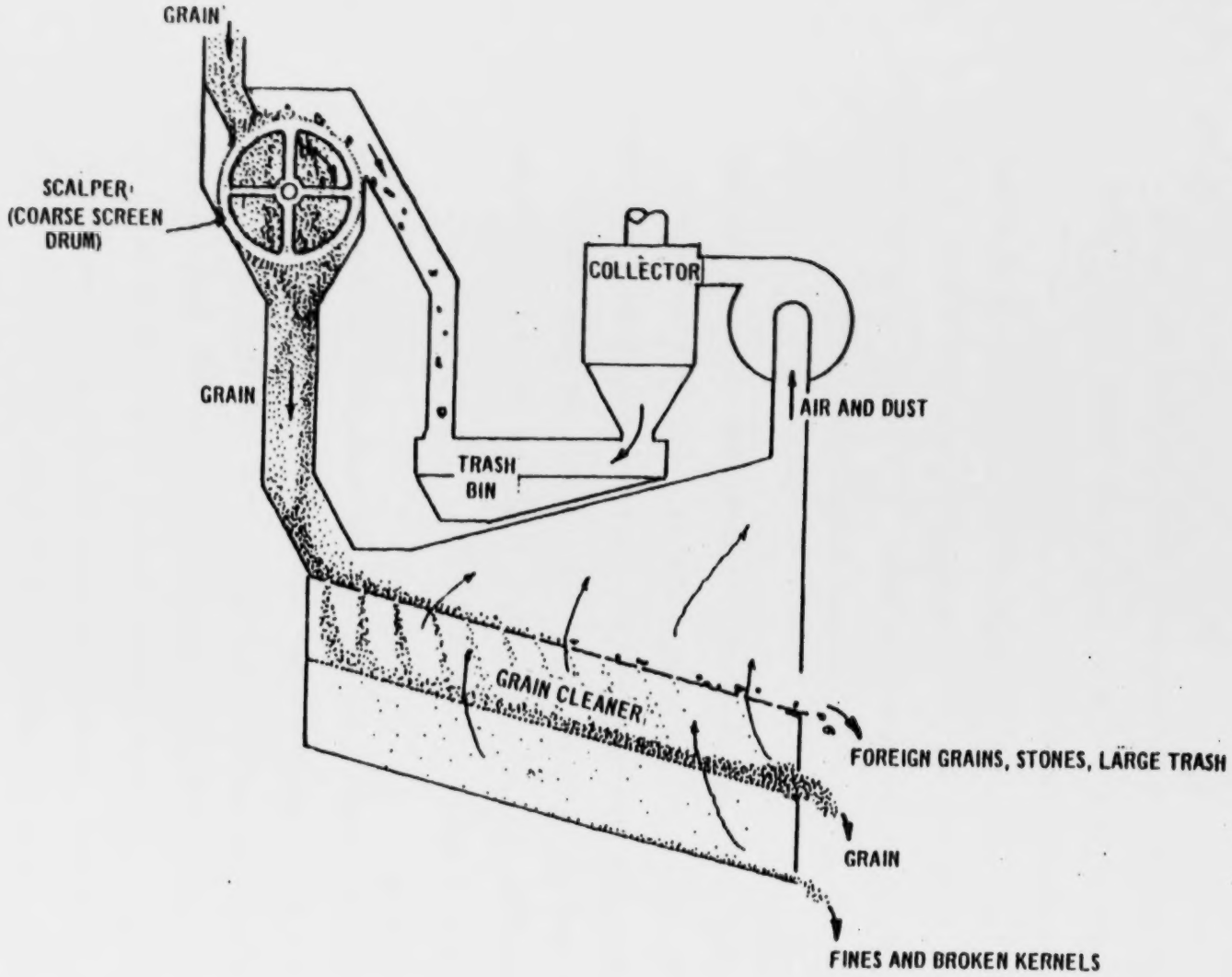
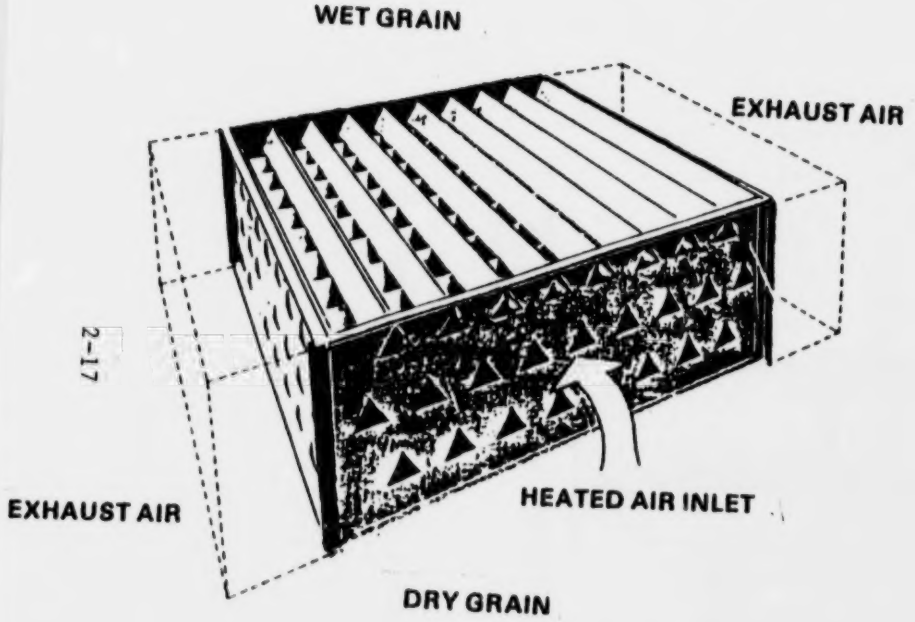


Figure 2-6. Grain cleaning.



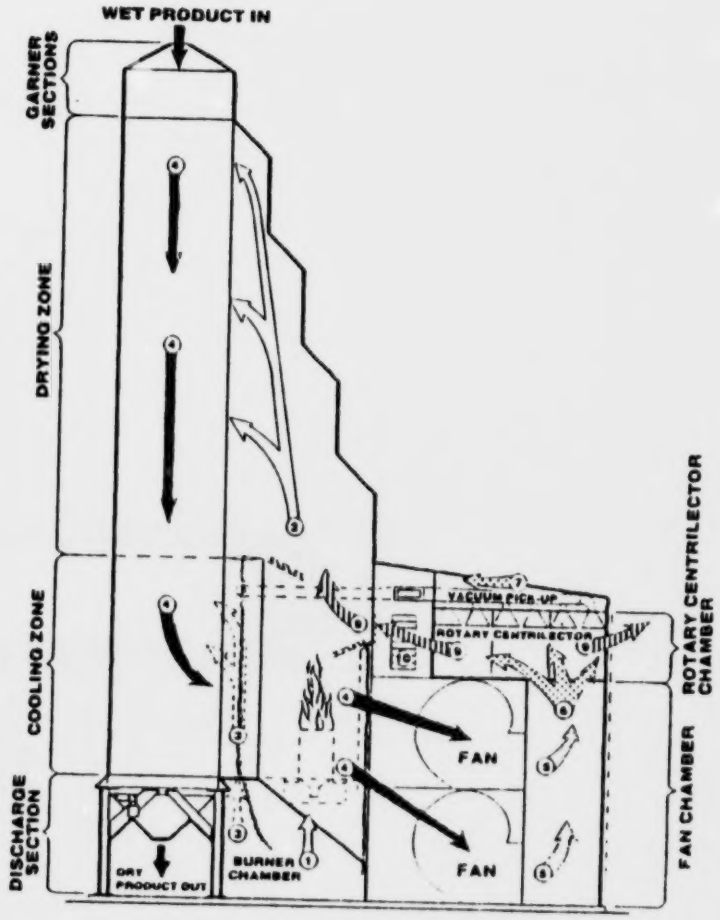


Figure 2-6. A Rack Grain dryer.

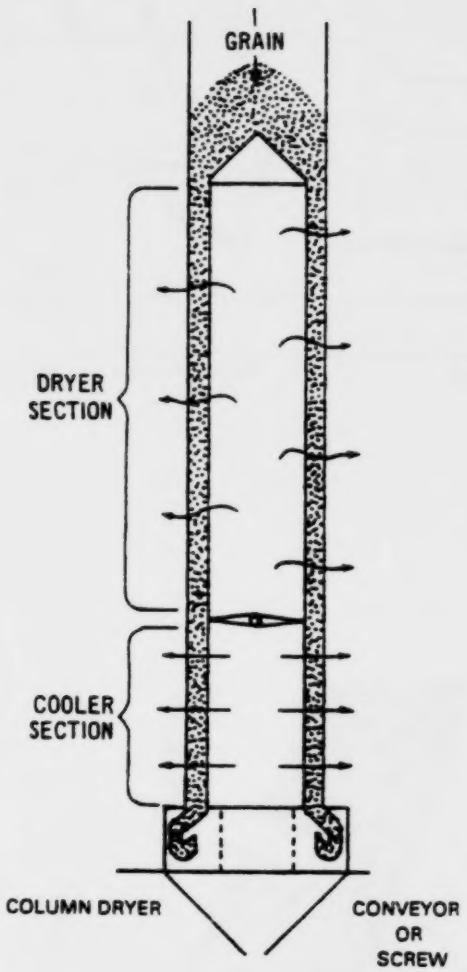


Figure 2-7. Column Grain Dryer.

Dust and chaff can become entrained in the air and carried from the dryer. The potential quantity of dust emissions is largely dependent on the type and model of dryer. In a column dryer the grain flows in a column between two perforated metal sheets to the bottom. Most of the dust is trapped within the grain and never reaches the side of the dryer. A rack dryer contains baffles or racks around which the grain and hot air must flow. This turning motion of the grain creates more beeswings and hulls (a major portion of dryer emissions) than are created by column dryers. The dryer is more open, also, since the air does not pass through metal sheets.

2.4.7 Loading

2.4.7.1 Trucks

Grain is shipped by truck from both country and inland terminal elevators. The grain to be loaded out may be weighed in the scale hopper and then dropped into the lower surge bin. It flows directly from the surge bin down a chute into the truck (see Figure 2-8). Grain elevators without hopper scales will load directly into the truck through the loading spout. Sometimes the loading area is not enclosed and wind that blows across the end of the loading spout entrains dust from the grain stream. Enclosing the truck loading area on at least three sides by using quick closing doors will greatly reduce the atmospheric emissions. Dust emissions can also be reduced by decreasing the free-fall distance between the end of the loading spout and the truck bed. This can be done with a telescoping loading spout or the loading spout can be surrounded by a canvas enclosure with a duct that can withdraw dust emissions to a control device.[15]

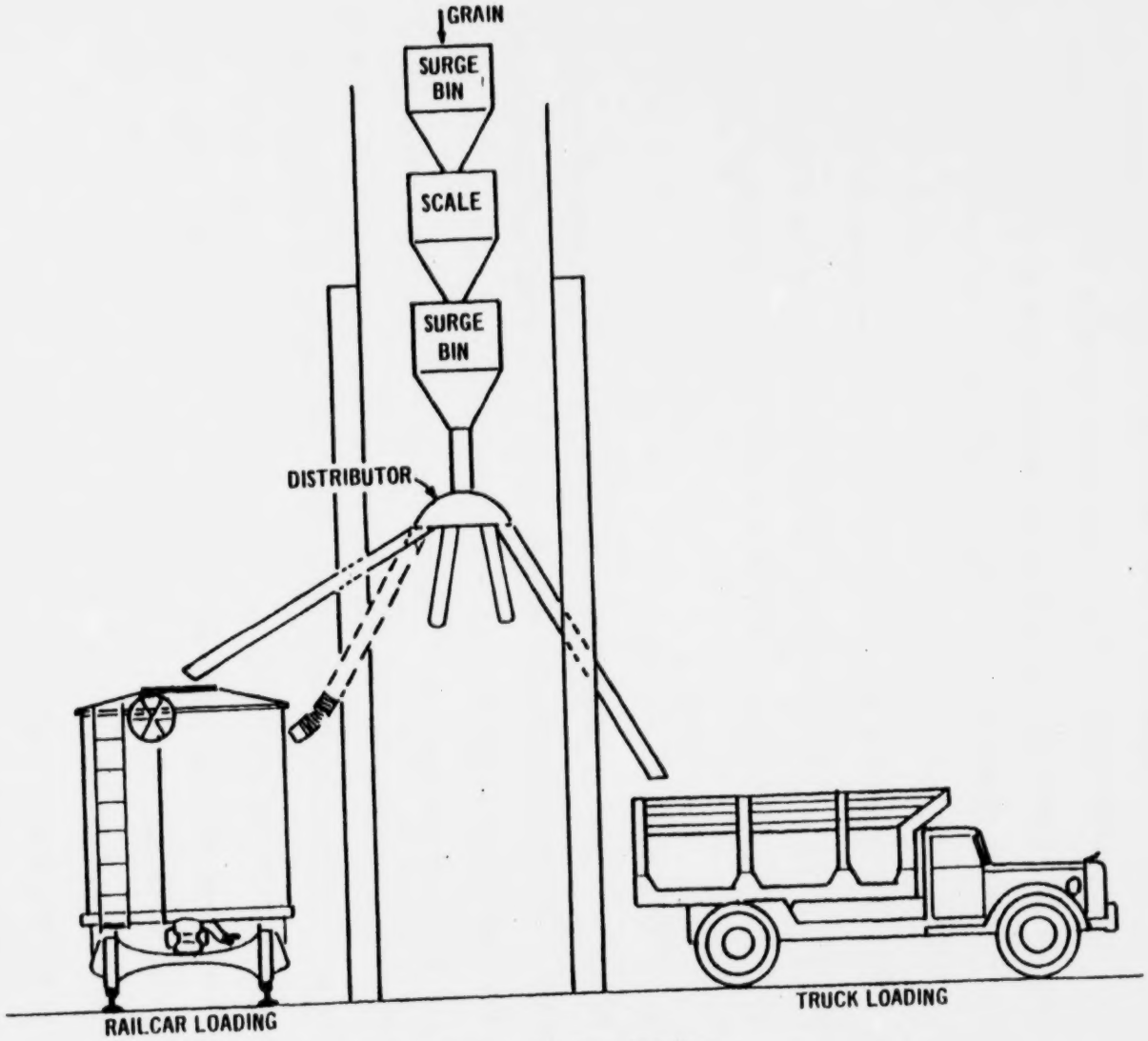


Figure 2-8. Truck and railcar loading.

2.4.7.2 Railcars

2.4.7.2.1 Hopper Cars - Grain is shipped by hopper cars from country and inland terminal elevators. They are loaded through either a long rectangular hatch down the center of the car or two rows of round hatch openings. If the grain elevator has a hopper scale, the grain to be loaded out is weighed in the scale hopper and then drops into the lower surge bin. It flows from the surge bin directly down a loading chute into the railcar (see Figure 2-8). Grain elevators without a hopper scale will load directly into the railcar through the loading spout. Dust is entrained in the air displaced from the car. Reducing the free-fall distance between the end of the spout and the top of the hopper car with telescoping loading spouts also lowers emissions. Also, the pouring spout can have an annular space around it through which the dust emissions can be withdrawn to a control device. The amount of dust escaping the car can be reduced by keeping hatch openings not being used closed or having flexible ducts placed in the openings which withdraw the dust emissions to a control device.[15]

2.4.7.2.2 Boxcars - Before a boxcar can be filled with grain, grain doors must be installed over the doorway in the side of the car. The grain door, constructed of wood or a heavy cardboard, covers about three-fourths of the height of the door opening. The grain is directed down a loading spout and through the opening above the grain door (see Figure 2-8). Dust is entrained in the air displaced from the car. A hooding system covering the door area with a duct or flexible ducts can withdraw dust emissions generated and reduce emissions to the atmosphere.[15] Industry sources indicate that very few boxcars are used anymore and probably will be eliminated in the future.

2.4.7.2.3 Barges - There are two mechanisms which result in emissions during the loading of barges. The first is when the grain drops from the loading spout into the barge (see Figure 2-9). Often, a free-fall distance of several feet between the end of the spout and the top of the barge allows wind to entrain dust from the grain stream. This free-fall distance can be reduced and emissions minimized by using telescoping loading spouts with an annular space at the end of the spout to capture dust emissions. Also, a choke feeder type pouring spout can be used to reduce the effect of the free-falling grain. The second is re-entrainment as the dust boils up from the hold. Barges can carry approximately 50,000 bushels of grain. The hold is usually covered with large steel hatches. To fill a barge, portions of the top must be uncovered. Some cover designs use several small hatches that one man can open. The smaller hatch openings minimize the surface area of the grain that is exposed to the wind.

2.4.8 Ships

Grain loaded into ships is conveyed from the scale to the loading dock where it drops down long spouts into the ship's hold at rates of 30,000 to 100,000 bushels per hour.

Fifty to 80-foot long loading spouts are not unusual. Emissions increase with the length of the spout because more dust is created by abrasion of the kernels as they bounce down the long loading spout. The velocity of the falling grain also increases, which causes an increase in the amount of air entrained in the grain stream. Strong winds, when present, also increase dust emissions by entraining dust from the free-falling grain

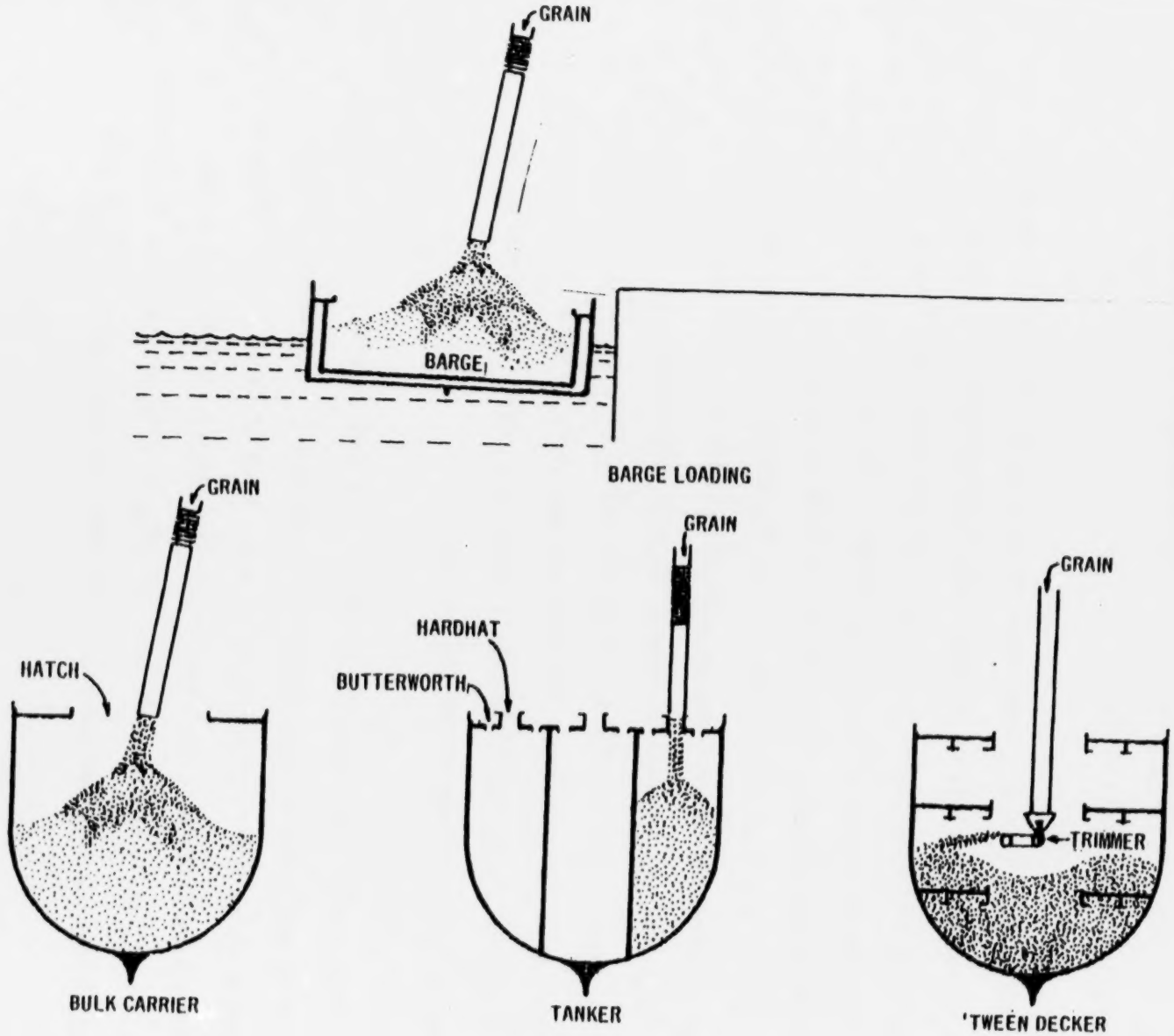


Figure 2-9. Barge and ship loading.

stream below the loading spout. Increased loading rates cause more rapid displacement of dust-laden air from the hold and also increase emissions. Three types of ships are used to haul grain. Each presents a different source of dust emissions (see Figure 2-9).

2.4.8.1 Bulk Carrier

The bulk carrier's hold is compartmented by a series of vertical bulkheads. There are no internal structures to hamper the loading operation. Hatch openings are large and permit easy access to all parts of the hold. The loading operation for this ship can be separated into three stages: (1) the initial buildup of a grain pile in the bottom of the hold, (2) filling to about the top 25 percent of the hold, and (3) "topping off" or filling the top 25 percent of the hold. Emissions are greatest during "topping off" because the wind can readily carry the dust away. The hold cannot be covered at this time because it is necessary to move the spout around rapidly to spread the grain. Therefore it is necessary to minimize the distance between the spout and the grain surface in order to reduce emissions. Newer facilities use a choke-type feeder which reduces the emissions during all phases of the filling operation.

2.4.8.2 'Tweendecker'

The hold of the 'tweendecker' is similar to a bulk carrier except that instead of an unencumbered open space, the 'tweendecker' has two horizontal intermediate decks (see Figure 2-9). The grain must be carefully stored under the intermediate decks to assure the hold is completely filled. Otherwise, the grain could shift which could cause the ship to list or capsize. To position the grain under the intermediate deck a "trimmer" or high-speed conveyor belt

is used to throw the grain from the loading spout. This trimmer generates a large amount of dust so that loading a 'tweendecker' results in more emissions than a bulk carrier. However, industry personnel report that very few tweendeckers are used to carry grain.

2.4.8.3 Tanker

A tanker is designed for transporting liquid in bulk, but is often used for grain (see Figure 2-9). Access to the holds is gained through two types of hatches. The primary hatch, the "hardhat," is three feet in diameter and is used for loading most of the grain. The "butterworth" is one foot in diameter. It is used for filling the small spaces which remain after filling throughout the hardhats. Less dust escapes during filling of tanker than other ships since they can be enclosed.

2.5 Selection of Grain Elevators for NSPS Control

There are about 15,000 grain elevators of various storage and handling capacities throughout the United States with the majority located in the grain belt areas. As specified in the Clean Air Act, the grain elevator NSPS applies only to those grain elevators with a permanent storage capacity of 2.5 million bushels or greater and grain storage elevators (mills) with permanent storage capacity of 1.0 million bushels or greater. Grain elevators were selected for NSPS development because they can be significant sources of particulate matter (PM). At the time of NSPS development, the nationwide emissions of PM from grain elevators were estimated to be 606,000 tons per year in 1971.[3] Using the model plant from Chapter 6, total uncontrolled PM emissions from this plant would be about 5400 tons per

year. Emissions from this plant without NSPS controls would be about 2600 tons per year. If the plant were to meet NSPS regulations, emissions would be reduced to about 100 tons per year of PM. Growth in the grain industry is expected to continue, but because of uncertainties of the world markets, surpluses, and governmental policies, the accuracy of any firm growth rates are suspect.

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3. CURRENT NSPS FOR THE GRAIN ELEVATOR INDUSTRY

3.1 Federal New Source Performance Standard

New source performance standards (NSPS) for the grain elevator industry were promulgated on August 3, 1978, limiting particulate matter and visible emissions from new, modified, and reconstructed grain elevator terminals (2.5×10^6 bushels storage capacity or larger) and grain storage elevators at flour mills (1.0×10^6 bushels storage capacity or larger).[1]

The standards limit particulate matter and visible emissions from the affected facilities at grain elevators as follows:

Affected Facility	Emission Limit
Fugitive Emissions	
Truck loading	10% opacity
Truck unloading	5% opacity
Boxcar and hopper car loading	5% opacity
Boxcar and hopper car unloading	5% opacity
Barge or ship loading	20% for all loading operations
Barge or ship unloading	Equipment standard: Marine leg enclosed from top to bottom of leg, with ventilation flow rate of both leg and receiving hopper of 40 ft^3 of air per bushel of grain unloaded.
Grain dryer	0% opacity or equipment standard: (1) column dryer-use of perforated plates with hole sizes no larger than 0.094 inch diameter. (2) Rack dryer-use of 50 mesh or finer screen.

Affected Facility	Emission Limit
Grain handling	0% opacity
Emission control device on air ventilated from affected facilities	0% opacity and 0.01 grain per dry standard cubic foot

Particulate emissions must be tested by Method 5 and visible emissions by Method 9. All process parameters must be monitored during the test period and the type of grain being handled must be identified. Where an equipment standard is required, the equipment must be inspected or certified information provided by the owner/operator that the equipment meets NSPS requirements. No continuous monitoring requirements to meet NSPS are required for the grain elevator industry.

3.2 State Emission Limitations for Grain Elevators

In general, only a few States have regulations that specifically pertain to existing grain elevator facilities. Those States that do not mention grain elevators as a specific industry usually have a process weight regulation that would include grain elevator processes (see Table 3-1).

For those States that specifically mention grain processes, the regulations usually vary depending upon the storage capacity of the facility. Facilities of 300,000 bushels of storage and under have regulations that require good engineering design and operating techniques and to not be a nuisance in their area. Facilities above 300,000 and below 2,000,000 bushels of storage are required to use good engineering design and operating practices, and if in a rural area, control device efficiencies are required to be 90 percent or better. If the facility

is in an urban area, the control device efficiency is increased to 98 percent or better. Existing facilities over 2,000,000 bushels of storage and new facilities usually have to meet the requirements of 98 percent efficient control devices, equipment design criteria, and specific ventilation rates similar to NSPS requirements. Finally, some States have a specific emission limitation on the control device. All States limit visible emissions to less than 20 percent opacity for new facilities and 40 percent opacity for existing facilities. Most States have accepted delegation of enforcing the NSPS for the grain elevator industry. Those States that have not accepted delegation of NSPS cite that they do not have the money or personnel at this time to handle NSPS regulation, or that State legislation has not provided a regulation to meet NSPS.

TABLE 3-1. TYPICAL STATE PROCESS WEIGHT REGULATIONS FOR GRAIN ELEVATORS

	Particulate Regulation	Opacity Regulation
1.	$E = (4.1)(p^{0.67}) \leq 60{,}000$ lb/hr	$\leq 20\%$
	$E = (55)(p^{0.11})$ minus $40 > 60{,}000$ lb/hr	
2. (a)	$E = (3.12)(p^{0.985}) \leq 40{,}000$ lb/hr	
	$E = (25.4)(p^{0.287}) > 40{,}000$ lb/hr	

E = rate of emissions in lb/hr.

P = Process weight in ton/hr.

(a) Texas regulation

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1. Federal Register, August 3, 1978, Part III, EPA, Standards of Performance for New, Modified, and Reconstructed Grain Elevators.

2. Environmental Reporter: State Air Laws. Volumes 1, 2, and 3.

4. STATUS OF CONTROL TECHNOLOGY

The review of the NSPS did not reveal any new control technology or techniques since NSPS promulgation, except for some experimental work with oil, water, and steam sprays discussed later in this chapter. However, many plants have made considerable improvements in controlling emissions by adding new control devices or replacing older, less efficient control devices, not only for environmental purposes but also to reduce explosion potential, improve working conditions, and other safety conditions. [25]

4.1 Particulate Control

Data from a questionnaire survey and plant visits of new or recently modified elevators that were required to meet the NSPS show the exclusive use of fabric filters as the control device.[1] Fabric filters find extensive use by non-NSPS elevators that are located in more heavily populated urban areas where State and local ageancies require more stringent control techniques, and are starting to find increased use in smaller elevators and country elevators as required by local and State control agencies or for safety reasons.

The typical modern fabric filter (see Figure 4.1) at an elevator handles 2000 to 50,000 cubic feet of air per minute depending upon the grain handling facility applied. Most are package units that can be supplied by several manufacturers. The filters operate under negative pressure with the fan pulling air through the system. Felted, synthetic

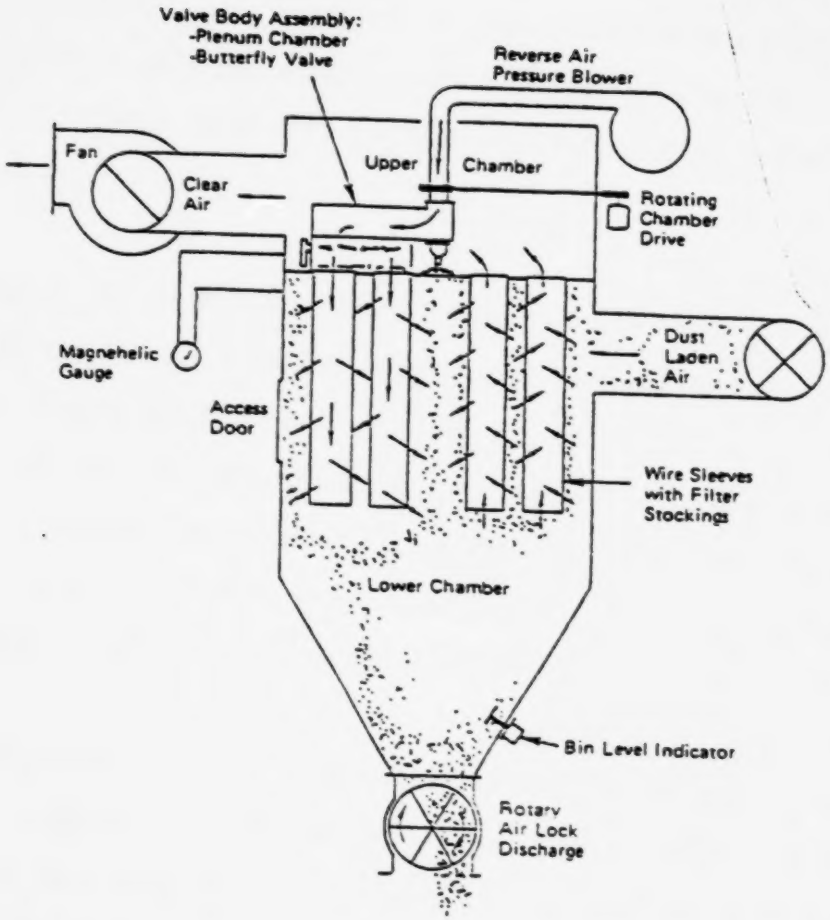


Figure 4-1. Typical Fabric Filter Used by Grain Elevators

fabrics are the most common collection media. The air-to-cloth ratios can range from 3:1 to 15:1, but are usually between 8:1 and 11:1. The filter bags are cleaned by reversing the air flow through them. Air flow reversal methods include forcing the dust cake off the fabric with back pressure; collapsing the cloth thereby cracking the dust cake; snapping the cake off with a pulse of compressed air; and blowing it off with a reverse jet which traverses the outside surface of the cloth. The fabric filters typically have efficiencies in excess of 99 percent, and a well operated and maintained unit will not have visible emissions.

Some non-NSPS elevators may still use cyclones, especially those elevators that are small, older, or located in rural areas. Cyclones are classified as either high-efficiency or high-throughput. High-efficiency cyclones are characterized by a narrow inlet opening, long body length relative to body diameter, and a small outlet diameter. The higher gas velocity in the cyclone results in a collection efficiency of about 85 to 95 percent. The pressure drop across a high efficiency cyclone may be 3 to 5 inches of water.

High-throughput cyclones have large inlet openings, large diameter bodies and large outlet diameters. The slower gas velocity results in collection efficiencies between 60 to 85 percent and pressure drops of only 0.5 to 2.0 inches of water. The major problems with cyclones are their low particulate matter collection efficiencies compared to fabric filters and their visible emissions.

The method of capturing particulate emissions for each grain elevator process in the industry is considered individually to show the most important differences. The techniques used for each process are discussed below.

4.1.1 Receiving (Unloading)

4.1.1.1 Trucks

Modern truck receiving hoppers are usually enclosed except for the ends (doorways). (Figure 4-2) The typical capture system consists of a collection of hood(s) spaced (Figure 4-3) around the receiving hopper. Also, hoods may be mounted either above or below the grate. Location below the grate is preferable because the resulting downward draft helps prevent escape of dust generated in the hopper. Specially designed baffles installed under the grate help retard the upward flow of dust-laden air out of the hopper (Figure 4-4).[10] This design is typical for some new truck and rail unloading systems. Such systems are typically designed for a face velocity of 200 feet per minute or more through the grate.[20] In the best controlled systems, the receiving hopper is enclosed on three sides with a door installed at the entrance that will automatically close when the safety stop for the truck is in place or is operator controlled. However, some truck unloading stations cannot close the door when unloading a hopper truck because the unloading station is not long enough. Although hopper type trucks do not generate as much dust as the end unloading trucks, some emissions could be carried outside the structure depending upon the velocity of the wind. The best truck unloading stations are those that are designed to be able to close the door for any type of

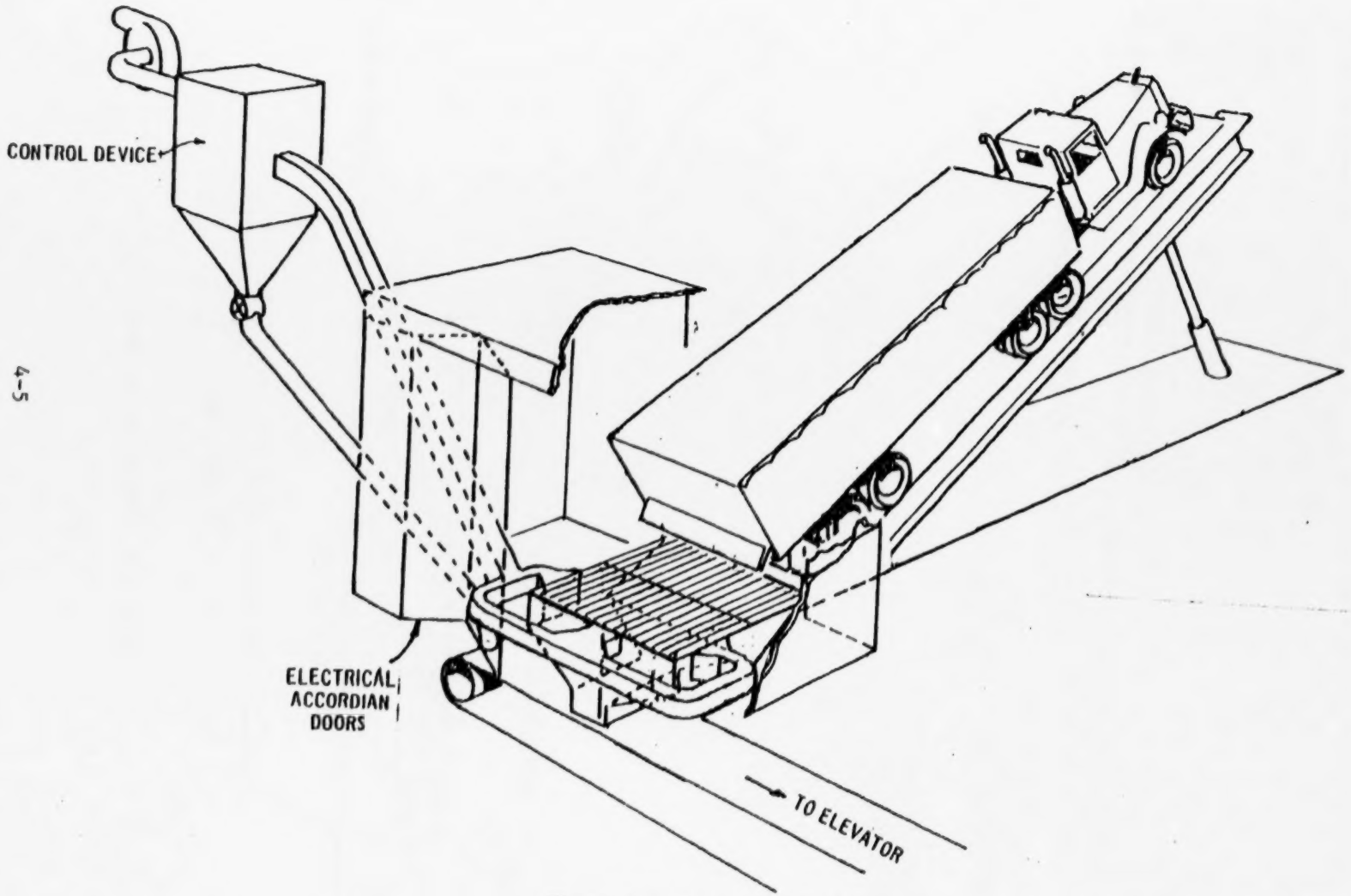
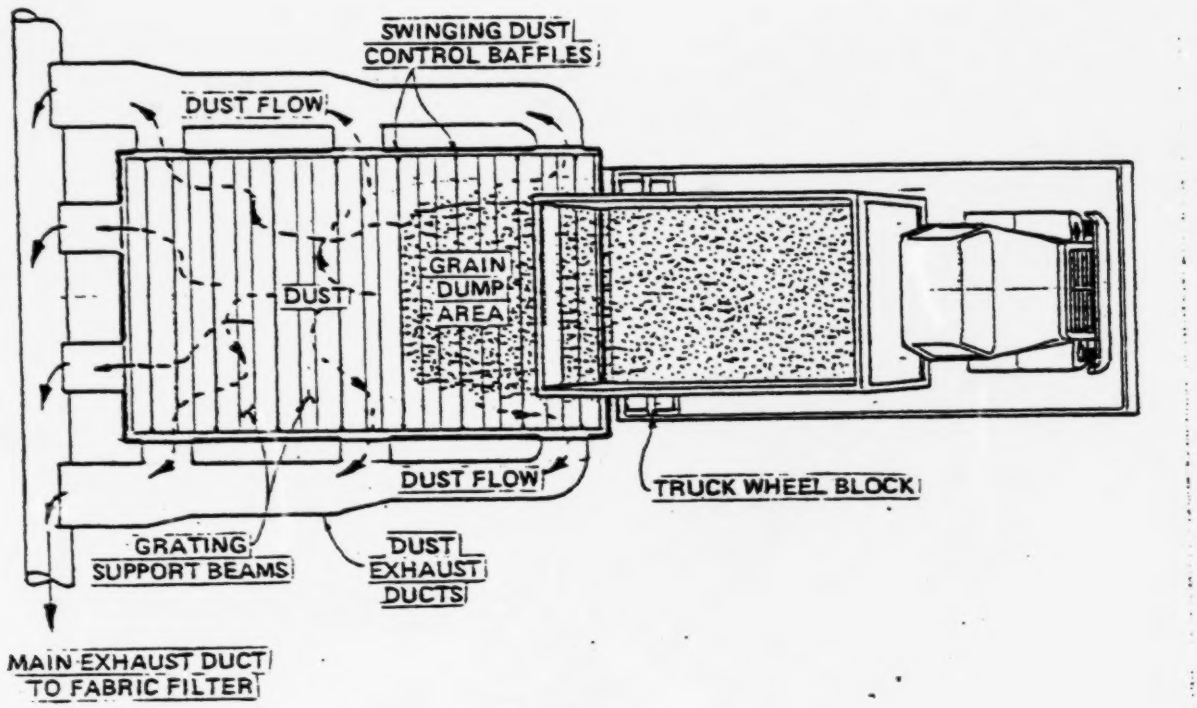


Figure 4-2. Truck unloading control system.



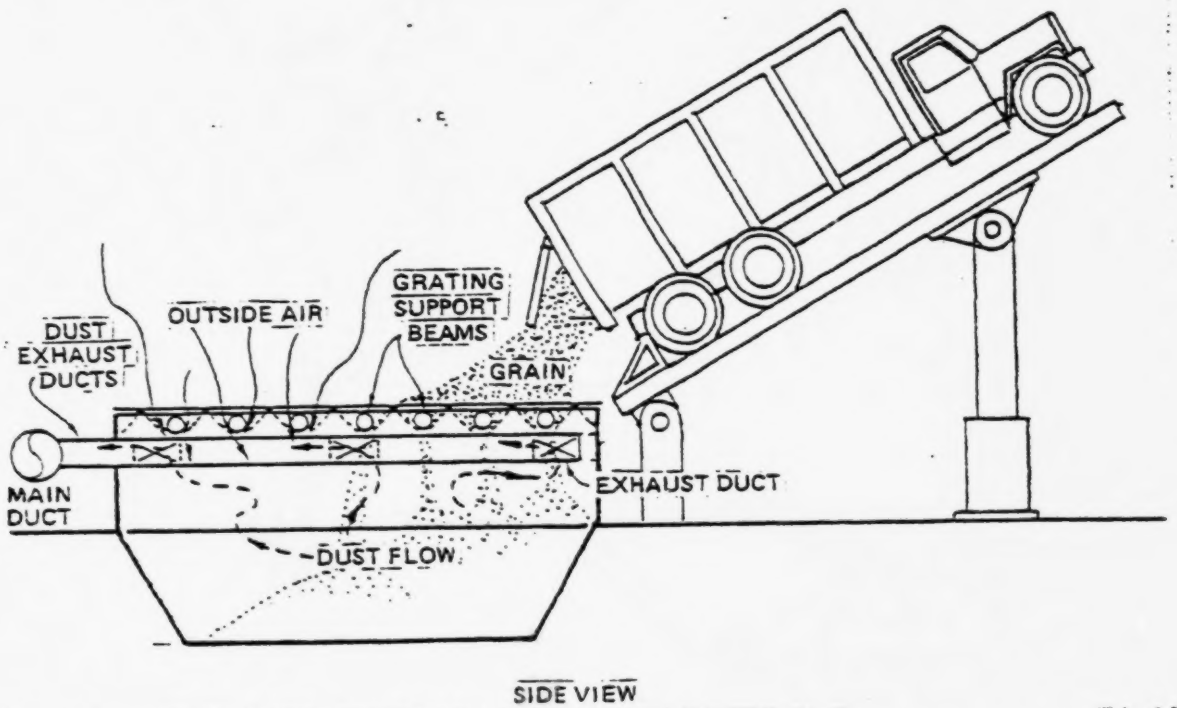


Figure 4-3. Truck grain dump facility.

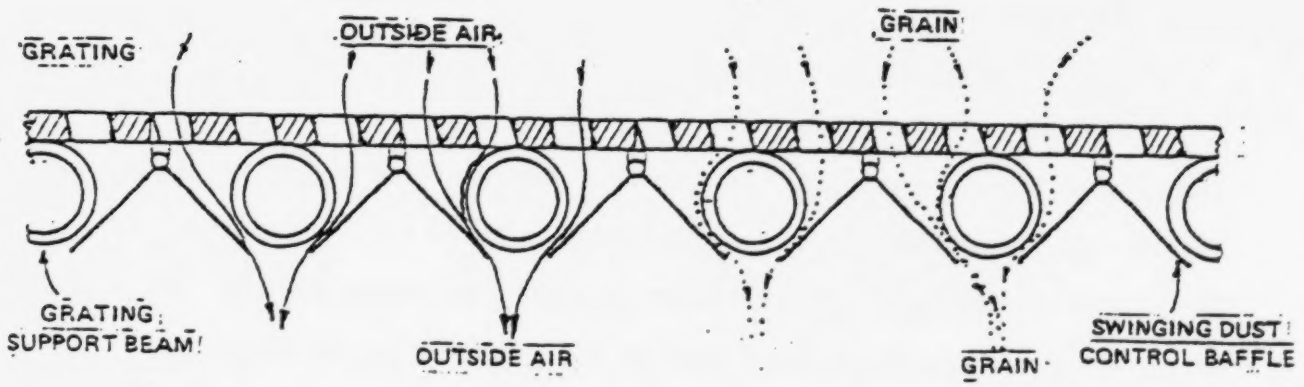


Figure 4-4. Beam and baffle detail.

truck.[20] The door should be closed before each truck is dumped. These two techniques prevent wind from interfering with the effectiveness of capture by the hood. There are little or no visible emissions of fugitive dust when the receiving area is enclosed on at least three sides during the unloading operation and the best capture system is used.[2,10] After capture, the dust is aspirated to a fabric filter.

4.1.2 Railcars

4.1.2.1 Hopper Cars

Hopper cars are sometimes unloaded using the choke feed concept to reduce or eliminate emissions. In this case the receiving hopper is usually shallow and the discharging grain forms a cone between the opening at the bottom of the hopper and the receiving grate (see Figure 4-5).[20] There may be a momentary cloud of dust as the receiving hopper fills, but very little during the remainder of the unloading operation as the grain slowly flows into the hopper. Walls around three sides of the receiving area or a skirt around the hopper will help prevent wind from blowing dust from the cone of grain. However, most large elevators use or unload unit trains and the closing of a door after each car (disconnecting and connecting process) could cause the train to be held an excessive length of time and result in penalties (demurrage) to the elevator.

Most new modern rail unloading stations seen during this review are quite large, and the emissions generated during unloading rarely reach the open doorways. Emissions from a deep receiving hopper are contained by aspirating dust from below the grate to a fabric filter. The efficiency of dust pickup can be increased by installing special baffles under the grate to

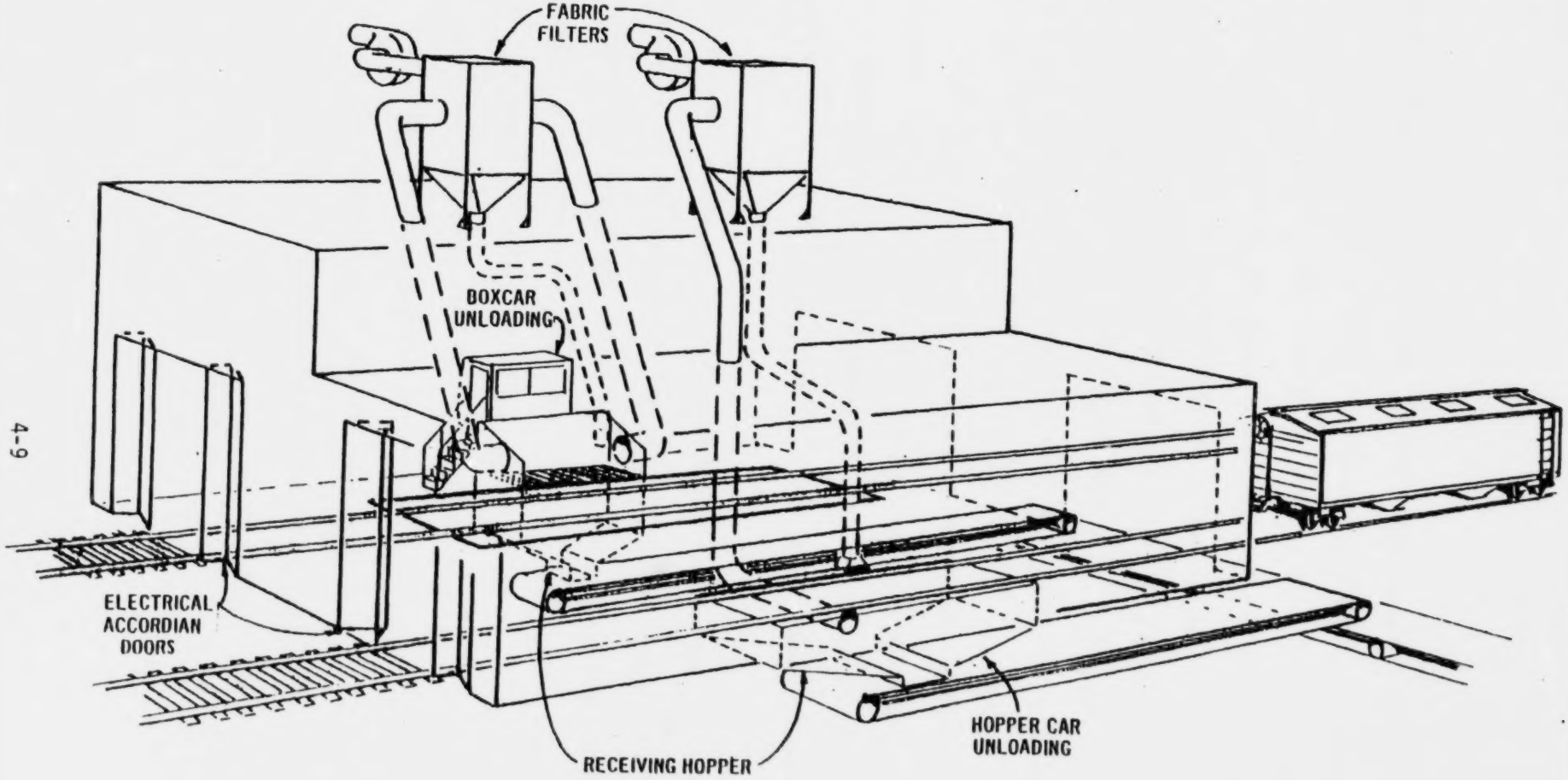


Figure 4-5. Railcar unloading control systems.

help retard the upward flow of dust-laden air out of the hopper as discussed in truck unloading. Such systems are typically designed for a face velocity of 200 feet per minute or more through the grate. The receiving area can also be enclosed on three sides, where unit trains are not used, to help prevent wind currents from decreasing the effectiveness of the dust capture system. Most modern elevators today use deep receiving hopper. There were few visible emissions of fugitive dust seen coming from the modern unloading or loading buildings and control systems visited during this review.[2,5,8]

4.1.2.2 Boxcars

Very few grain elevators handle boxcars anymore and grain elevator operators have indicated that the days of the boxcar are numbered. Several elevators visited during the review had closed their boxcar unloading facility. However, those in use are similar in design to those for hopper cars.

Two unloading methods are used for boxcars.[20] One method is breaking a grain door (heavy paper) inside the regular car door opening. This produces a surge of grain and dust as the grain falls into the hopper. The remaining grain is scooped out by hand or tractor and each scoop produces a surge of dust. Since most of the dust is generated in the receiving hopper, it is usually captured by special hoods located below the grate and aspirated to a fabric filter (see Figure 4-5). Baffles installed under the grate help prevent the upward flow of dust-laden air out of the hopper. The efficiency of dust pickup is improved by stopping wind action with a flexible enclosure around the car door (Figure 4-6).

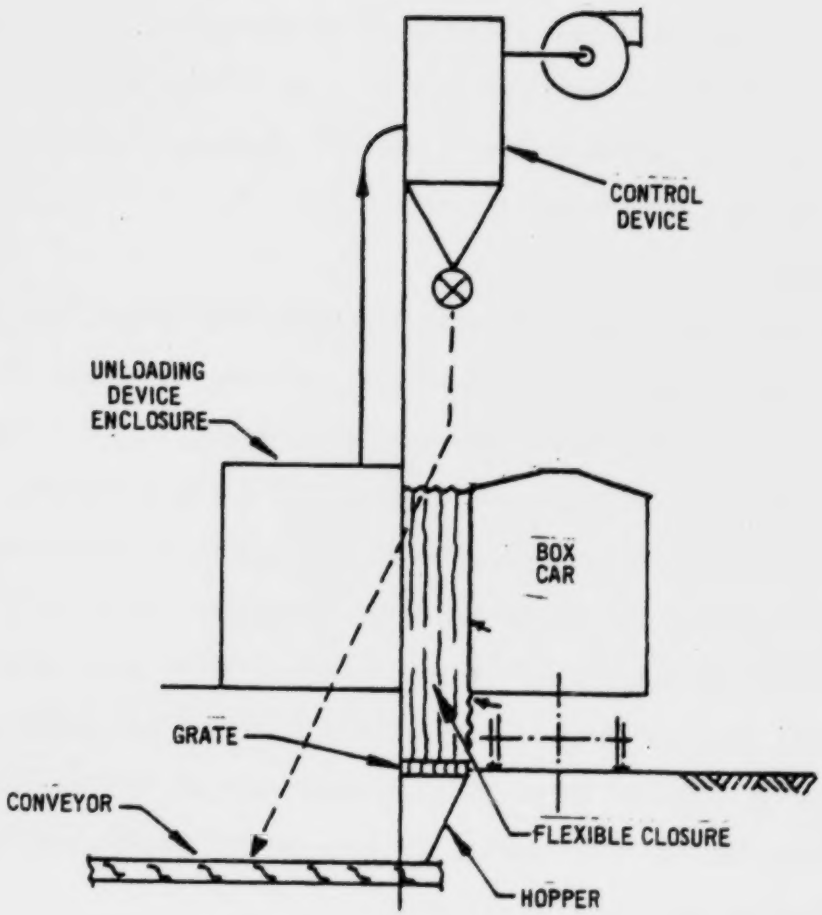


Figure 4-6. Boxcar unloading control system.

Another common boxcar unloading method is a mechanical boxcar dump which picks up and tilts the boxcar to dump the grain. This rapid unloading creates a large surge of dust which is difficult to contain unless the unloading facility is completely enclosed. Capture systems for these facilities are typically designed for a face velocity of 200 feet per minute or more through the grate.[20] There are reportedly little or no visible emissions of fugitive dust when the best capture system is used.[14] No boxcar facilities were in operation during plant visits in this review.

4.1.3 Barges

To minimize emissions from unloading grain from barges, the bucket elevators (marine legs), receiving hoppers, and conveyor belts are enclosed. Dust is aspirated from the enclosures to a cyclone or fabric filter (Figure 4-7). Good maintenance of the enclosures is essential for good capture. The NSPS requires that the marine leg be enclosed from top to bottom (except where it is necessary to have the bottom pulley portion open - Figure 4-7) and have a ventilation flow rate of 40 ft^3 of air per bushel of grain unloaded. Also, newer marine legs use large plastic buckets to handle the grain and the leg can operate at a slower speed, thus not generating as much dust when picking up the grain, but still delivering the same or more bushels per hour.[2,3,8,9,20]

4.1.4 Handling and Conveying Equipment

4.1.4.1 Transfer Points

Screw conveyors are enclosed and are operated slowly (usually about 100-175 feet per minute) so that no dust is emitted. Drag conveyors are also totally enclosed and normally not aspirated. Hoods are needed on

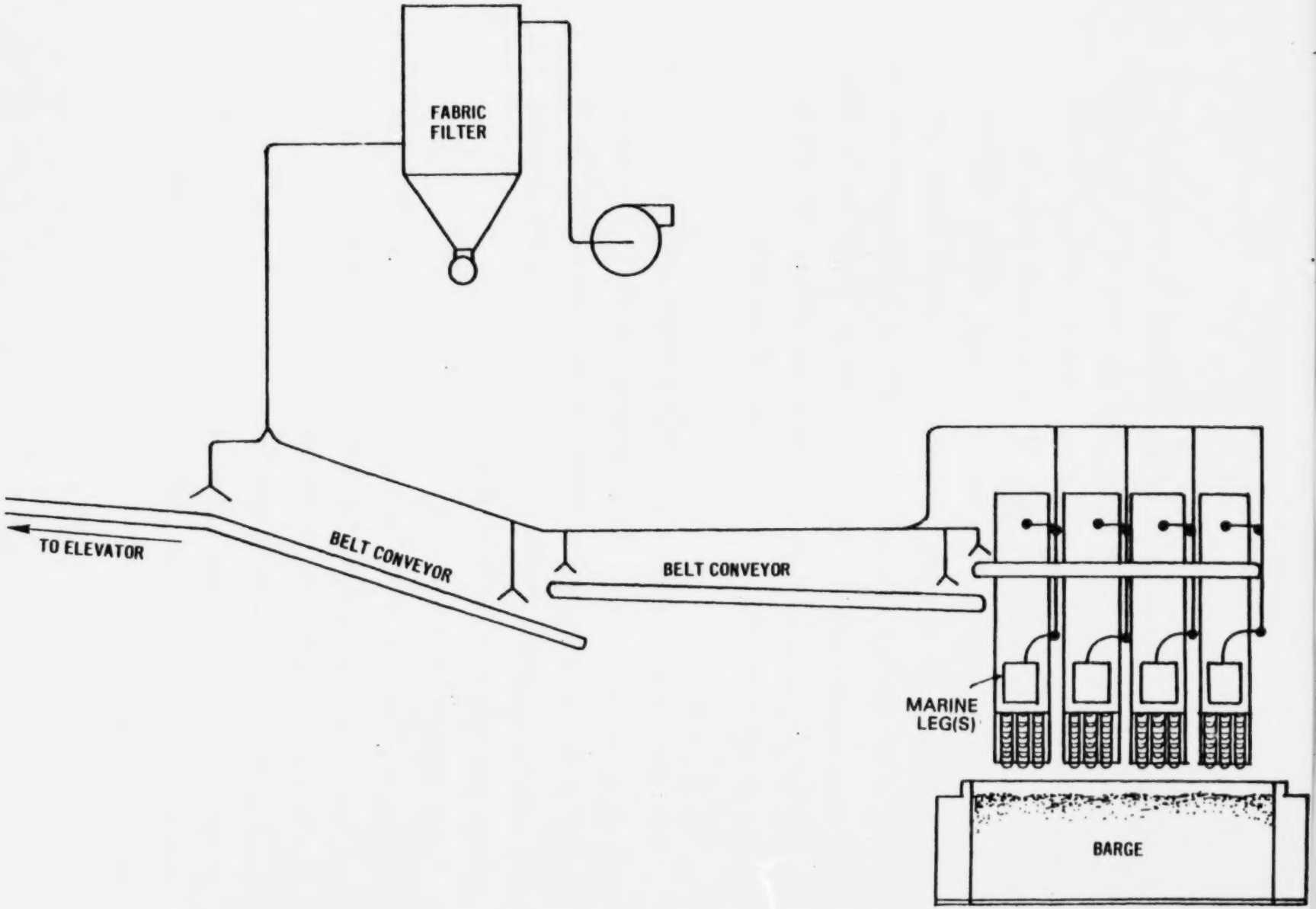


Figure 4-7. Typical barge receiving control system.

belt conveyors only at points where the grain is to be transferred (i.e., where it enters or leaves the belt) or when they are located out of doors. Otherwise, a column of air travels with the conveyor and does not disturb the grain dust. Sometimes, if transfer points are close together, the belt is hooded along its entire length. Modern elevators, recently visited, usually hood the entire conveyor system. The capture velocity of air into the hood should be 100 feet per minute faster than the speed of the conveyor belt (500-800 feet per minute) to overcome the laminar layer of air that accompanies the grain away from the hood. Air and dust are aspirated from the hoods to fabric filters (Figure 4-8).

4.1.4.2 Legs

When grain enters the bottom of a "leg" or bucket elevator, a positive pressure is created at the top. It is necessary to relieve this pressure by venting the leg to an emission control device. Dust can build up in legs creating explosive conditions; therefore, some insurance companies require that they be vented to minimize this possibility.

New elevator legs may have large plastic buckets and the leg is designed to allow it to operate at a slower speed, thus not generating as much dust. The larger buckets (Figure 4-9) allow a greater handling capacity and the plastic construction reduces the chances of sparks being caused in the leg and attendant explosions. There are no visible emissions of fugitive dust when the best enclosures and/or aspiration systems are used (Figure 4-9), and none were seen from the legs during plants visits for the NSPS review.[2,4,6,8,9,10,12]

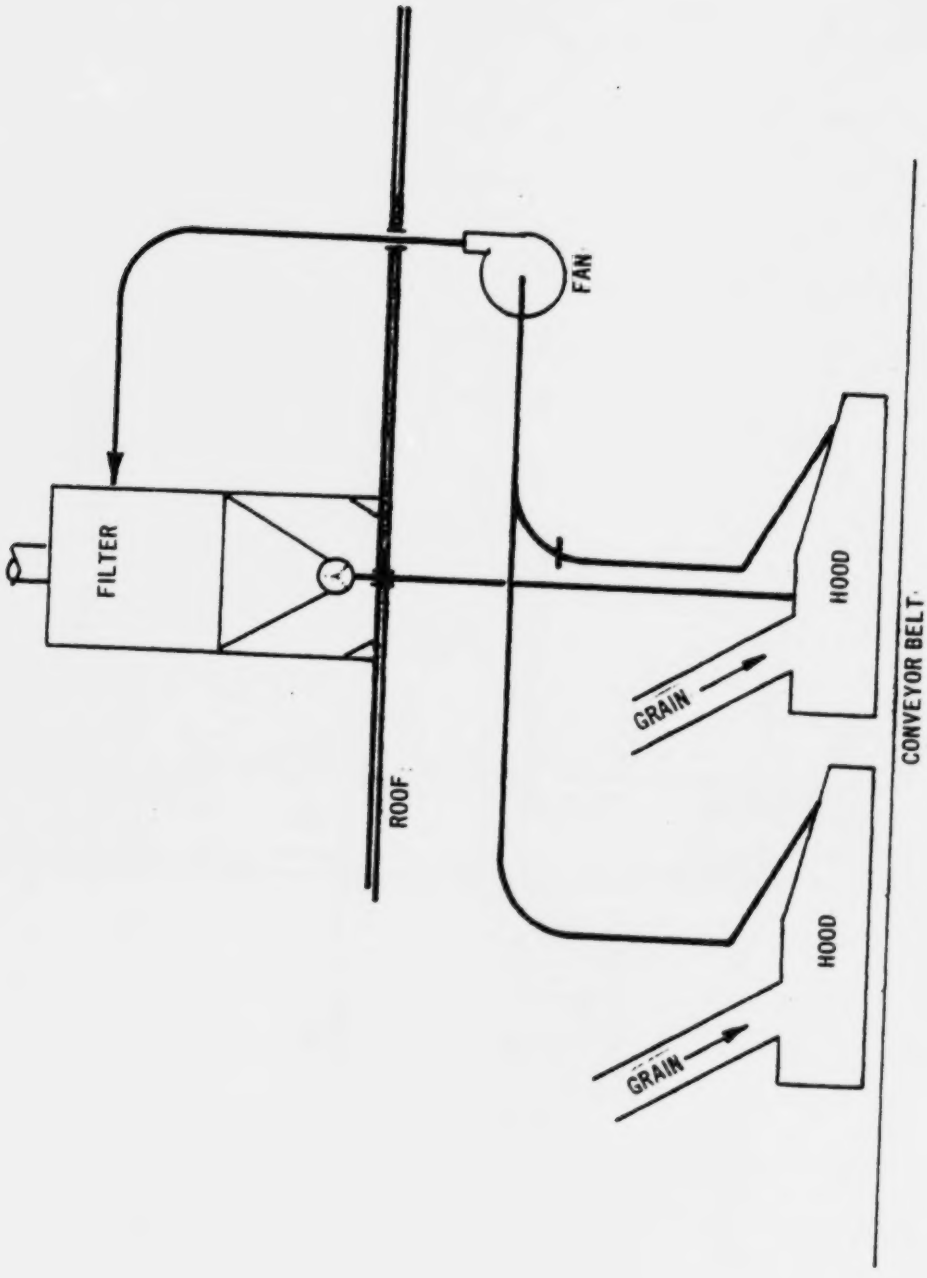


Figure 4-8. Transfer point control system.

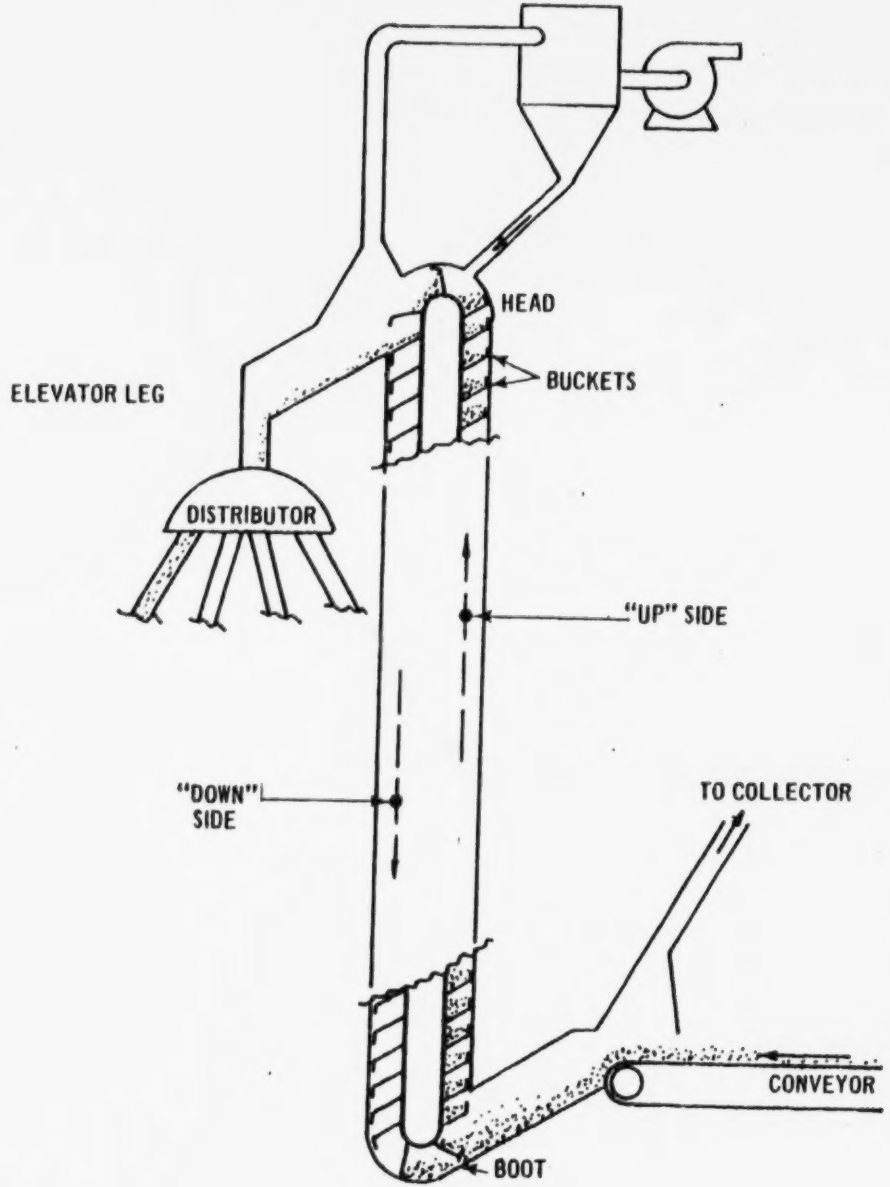


Figure 4-9. Elevator leg.

Some new elevators have eliminated legs feeding the storage silos and use only conveyor systems. The major reason for this is that the legs are considered the largest generator of dust within a grain facility, therefore, have the greatest potential for explosions. Conveyor belt systems reduce this hazard considerably.

4.1.4.3 Scales and Garners

A scale hopper or bin and the associated surge bins (garners) may be vented to a common collector (Figure 4-10). Fabric filters are the major control device. There are no visible emissions of fugitive dust from the bins when the best capture and control system is used.[2,4,6,8,9,10,12]

4.1.4.4 Storage Silos

In the past, emissions from silos were not visible; therefore, they were not controlled because the tops of the silos were usually interconnected, which eliminates atmospheric emissions. Howerver, as a fire and safety precaution, modern plants and many recently modified plants do not interconnect silos. In some modern elevators, storage silos are aspirated to a fabric filter (Figure 4-10).

4.1.4.5 Cleaning

Emissions from screen cleaners are controlled by hooding or partially enclosing the cleaner and aspirating the dust to a cyclone or fabric filter (see Figure 4-10). The more thorough aspiration-type cleaners use tight enclosures around the screens and more suction to lift out light impurities. Some modern elevators use screen cleaners which have air-tight enclosures and required no aspiration or emissions control device. There are no visible emissions of fugitive dust when enclosed equipment or the best capture and control system is used.[14]

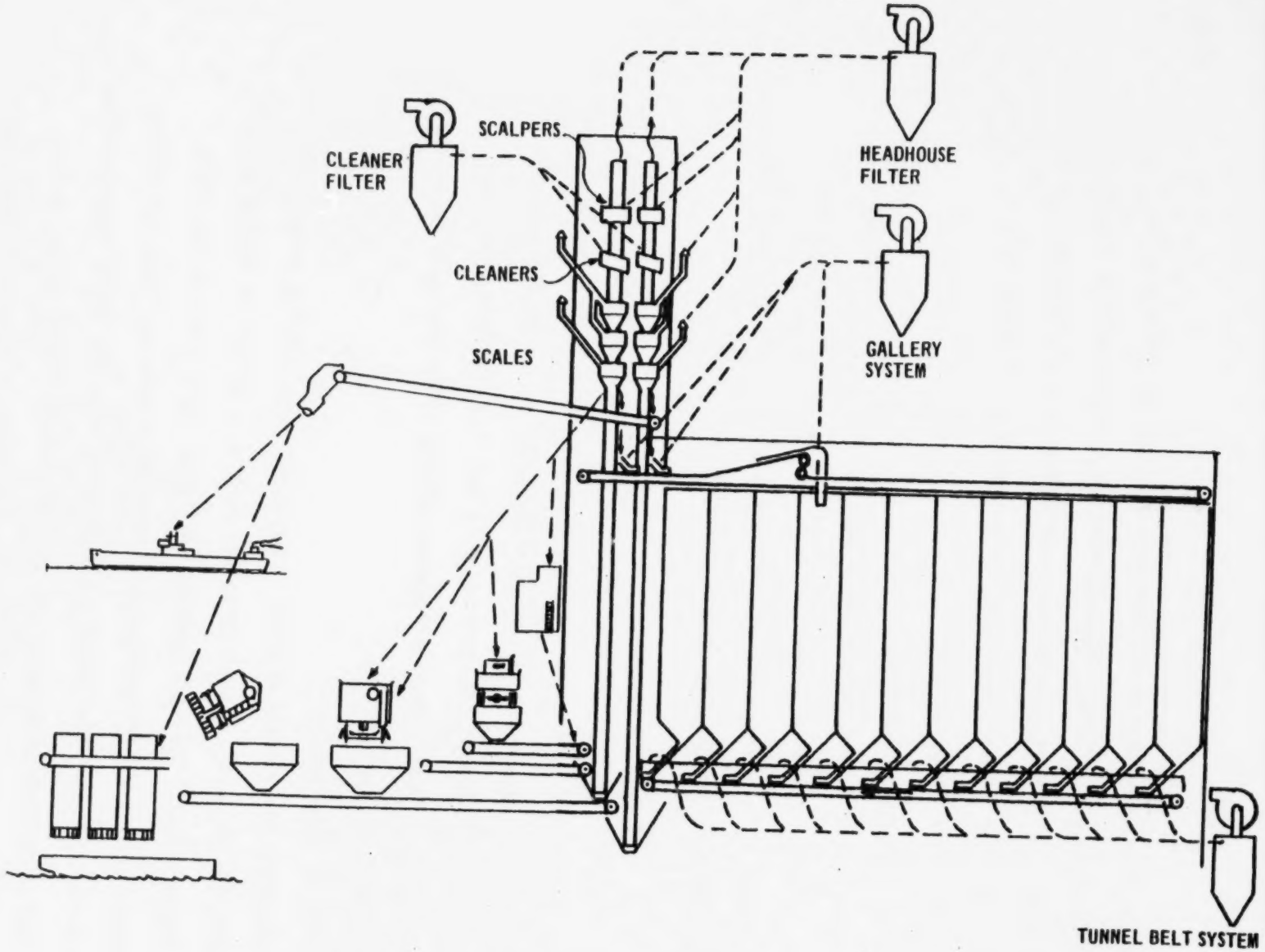


Figure 4-10. Grain handling and cleaning dust control system.

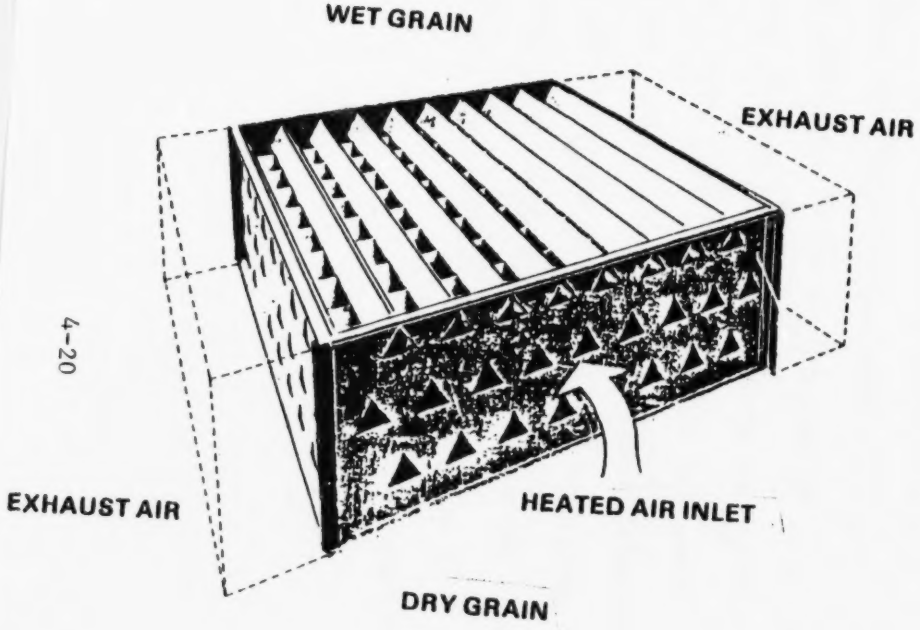
4.1.4.6 Drying

There are two types of dryers used in the industry, column and rack or cross baffle (Figures 4-11 and 4-12).[12,22] Both dryers use heated air which dries the grain as it moves down the heating zones of the dryers.

In a column dryer the grain passes down between perforated plates and the heated air is forced through the grain from inside to the outside. It has been shown that column dryers with column perforation plate hole diameters of 0.094 inch or less will achieve zero percent opacity.[14] There were no visible emissions seen from column dryers in operation at one plant during this review.[9]

Another dryer being used in the industry uses a wire screen with rectangular openings of 0.0486 inch by 0.5 inch. This screen size opening has been found in compliance with the NSPS.[19]

In a cross baffle or rack dryer, the drying air with particulate matter is cooled and goes to a rotary drum system covered with a 50 mesh polyester screen. The screen separates the particulate matter out of the gas stream and the gases passing through the screen can go to a control device for further cleaning, or in newer and more energy efficient units, allow some of the gases to be recirculated back to the heating cycle. Vacuum heads continually clean the screen and the particulate matter is returned to the product cycle or sent to the dust bin. No rack dryers were seen in operation during this review. There are reportedly no visible emissions using the best system of capture and control.[14]



CROSS-BAFFLE DRYERS

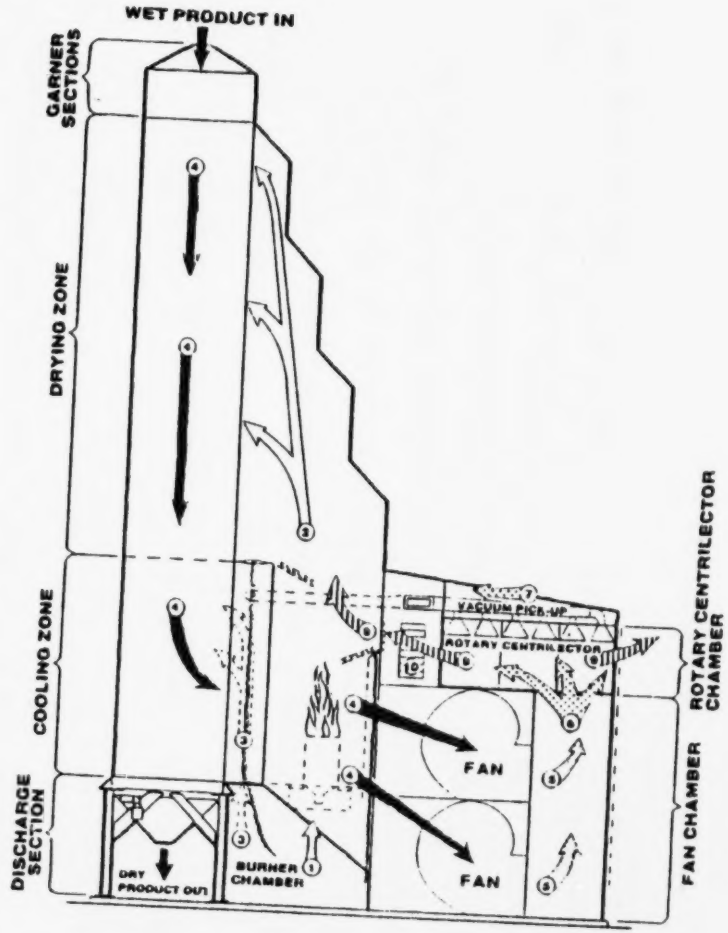


Figure 4-11. A Rack Grain Dryer

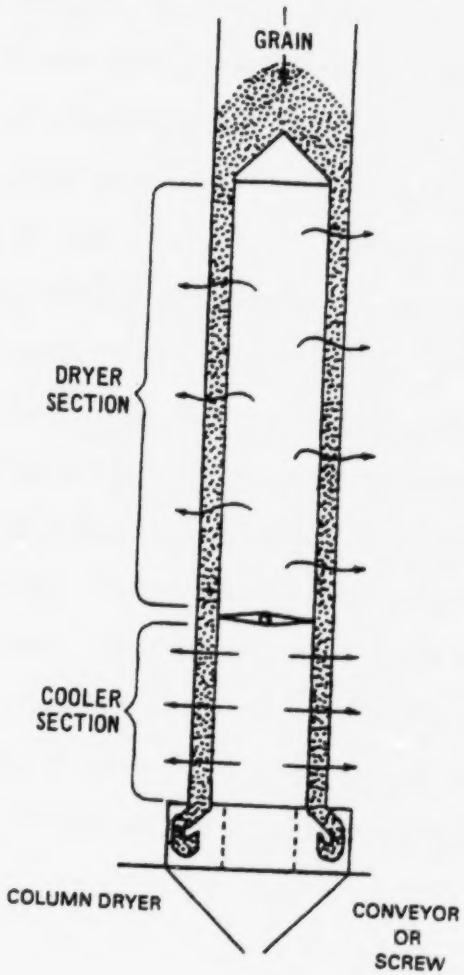


Figure 4-12. Column Grain Dryer

4.1.5 Loading

4.1.5.1 Trucks

Very few truck loading stations have aspiration type control systems, mainly because loading trucks at most terminal elevators is a very small part of their loading of grains. Emissions from truck loading can be minimized by reducing the free-fall distance between the end of the loading spout and the truck bed. This can be accomplished with a telescoping spout (Figure 4-13). The height of a telescoping spout can be adjusted quickly to any level to maintain it at the surface of the grain. Another more modern system is to use the telescoping system with a choke or controlled feed (Figure 4-14). The controlled feeder slows the velocity of the grain as it comes down the spout and reduces the formation of dust. Also, the dust can be aspirated to a control device in the annular air space around the pouring spout. A permanent hood would not be efficient because of the variety in size and height of the trucks. Capture can be improved if the loading area is enclosed on three sides. There are little or no visible emissions of fugitive dust when the loading area is enclosed and a telescoping loading spout or choke feeder is used.[14,23] Truck loading is rare at large grain elevators and is usually confined to small elevators.

4.1.6 Railcars

4.1.6.1 Hopper Cars

Emissions from hopper car loading can be similarly minimized by use of a telescoping loading spout or choke feeder as discussed for trucks (Figure 4-15).[14,23] All hatch doors on the car should be kept closed except for the one grain is entering. This allows the car to act as its own settling chamber.

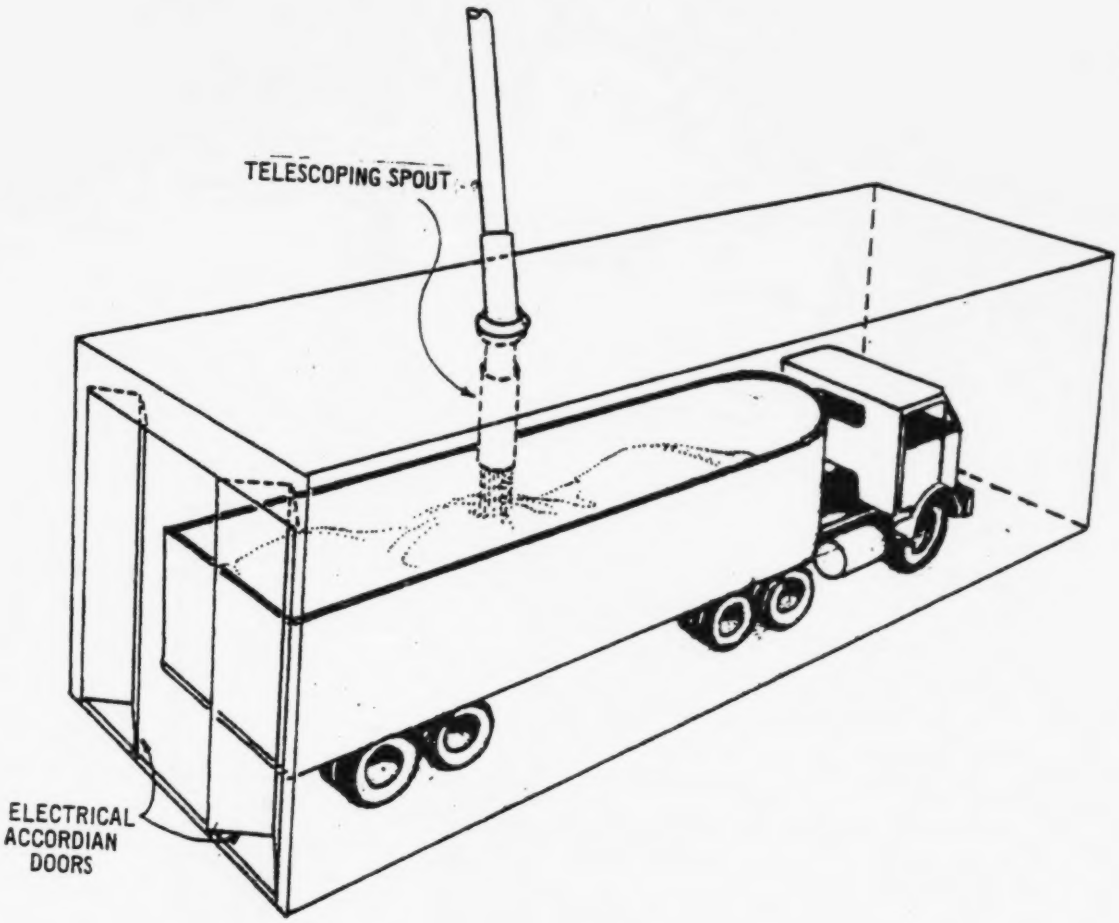


Figure 4-13. Truck loading control system.

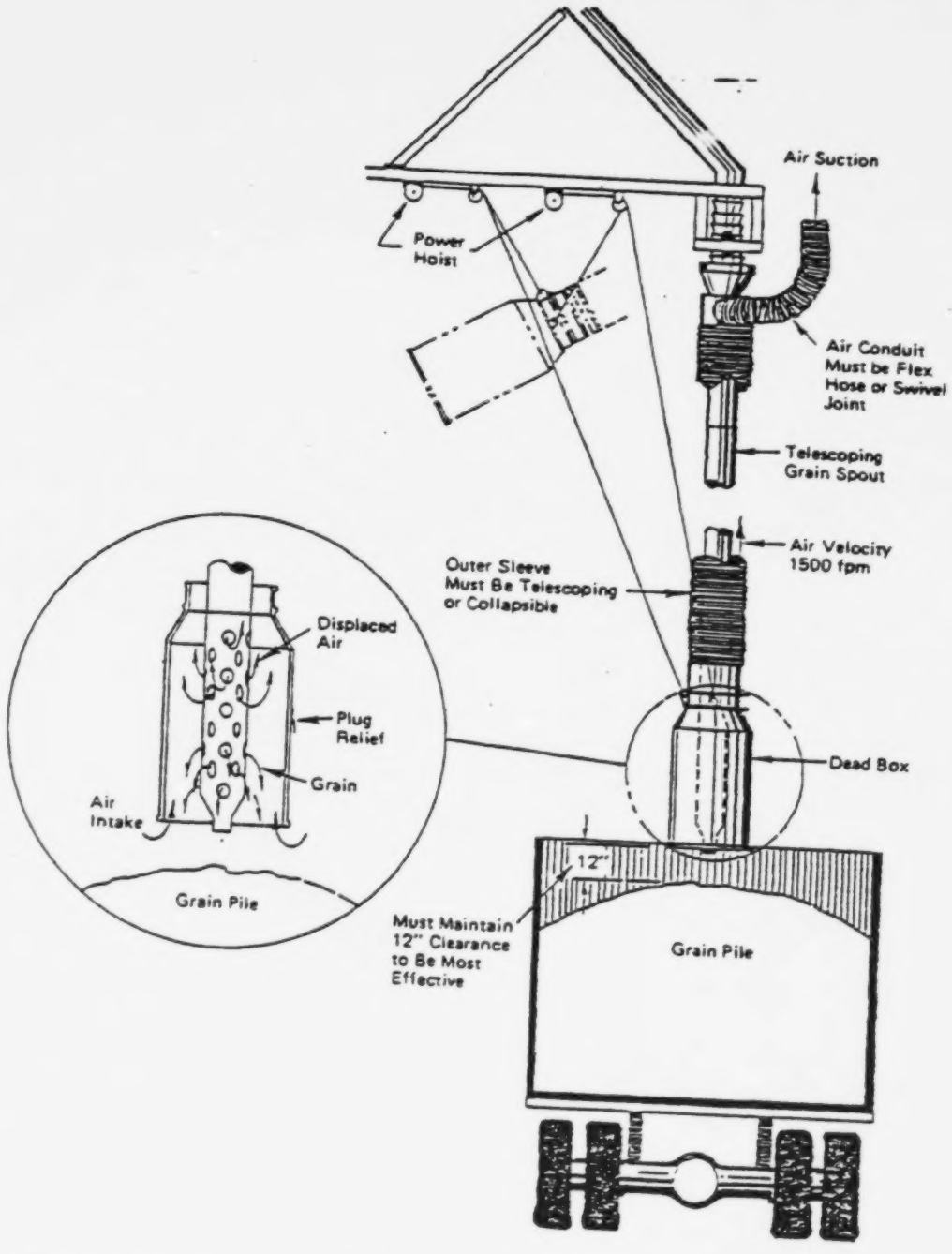


Figure 4-14. Retractable spout deadbox for truck load-out.

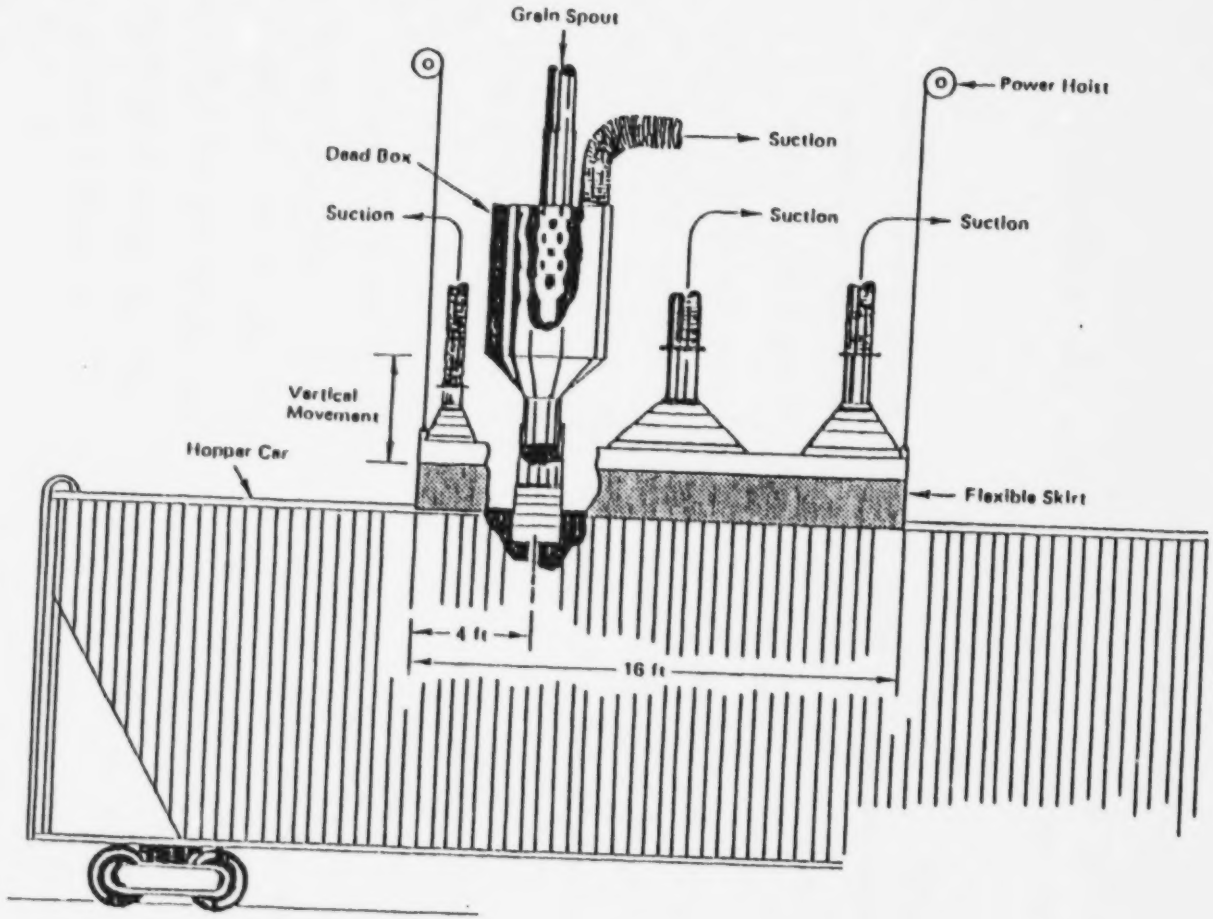


Figure 4-15. Combination deadbox with suction hood.

Another technique used is to install a hood at the discharge of the loading spout or on one of the hatch doors not being used and aspirate the dust to a control device. The hatch doors must be kept closed and control will be further improved if the loading area is enclosed. There are little or no visible emissions of fugitive dust when good capture systems are used.

4.1.6.2 Boxcars

Presently, there are very few boxcar loading stations and most do not use any type of control device. However, these emissions can be captured by a hood located beside the track (Figure 4-16). A flexible accordian-type enclosure should be extendible from the hood to the door of the car. The dust can then be aspirated to a control device. There are little or no visible emissions of fugitive dust when the best capture system is used.[14,23]

4.1.7 Barges

Emissions from barge loading can be minimized by reducing the free-fall distance from the end of the spout to the grain surface as discussed previously. Also, a choke-type feeder could be used as discussed in the truck loading section, and openings not being used should be closed. In addition, aspiration from the discharge end of the spout can be applied (Figure 4-17). Visible emissions of fugitive dust seldom exceed 10 percent opacity when the spout is kept at the surface of the grain or choke-feeder used, and dust is aspirated from the end.[14,24] The dust aspirated from the end of the spout is usually collected in a fabric filter.

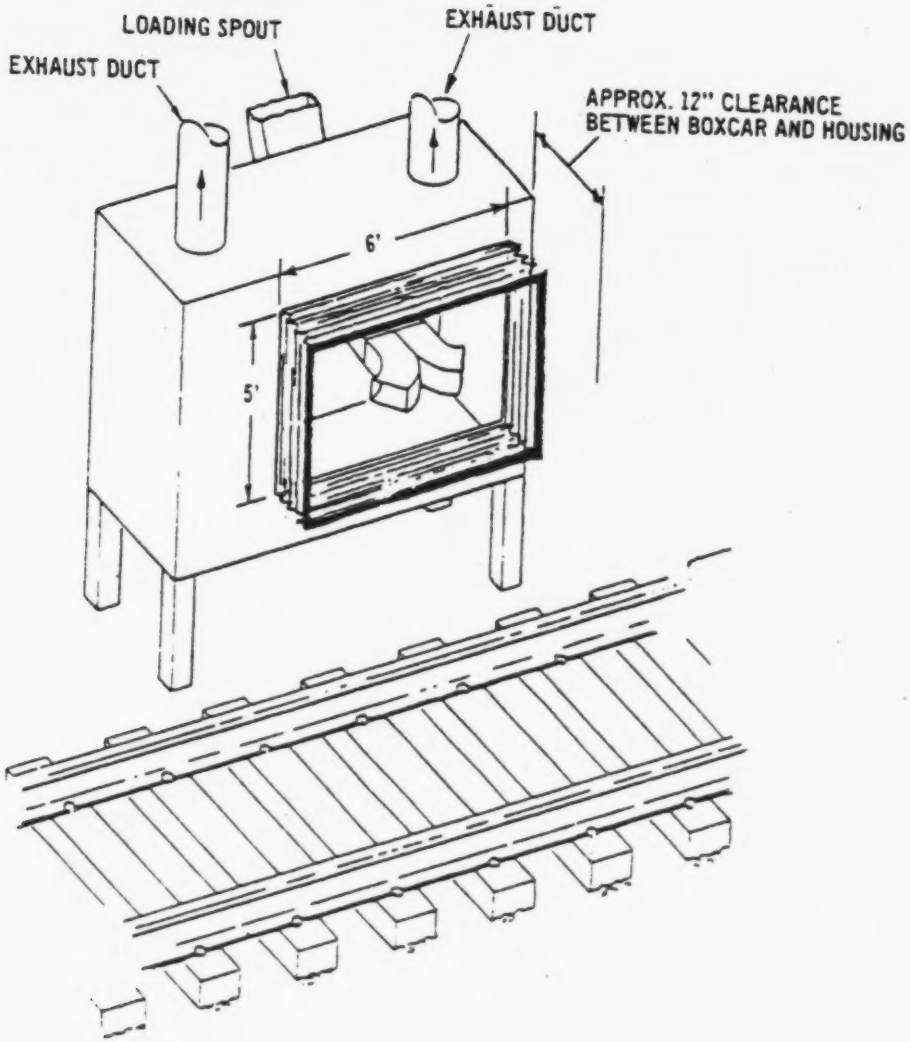


Figure 4-16. Dust control system for boxcar loading.

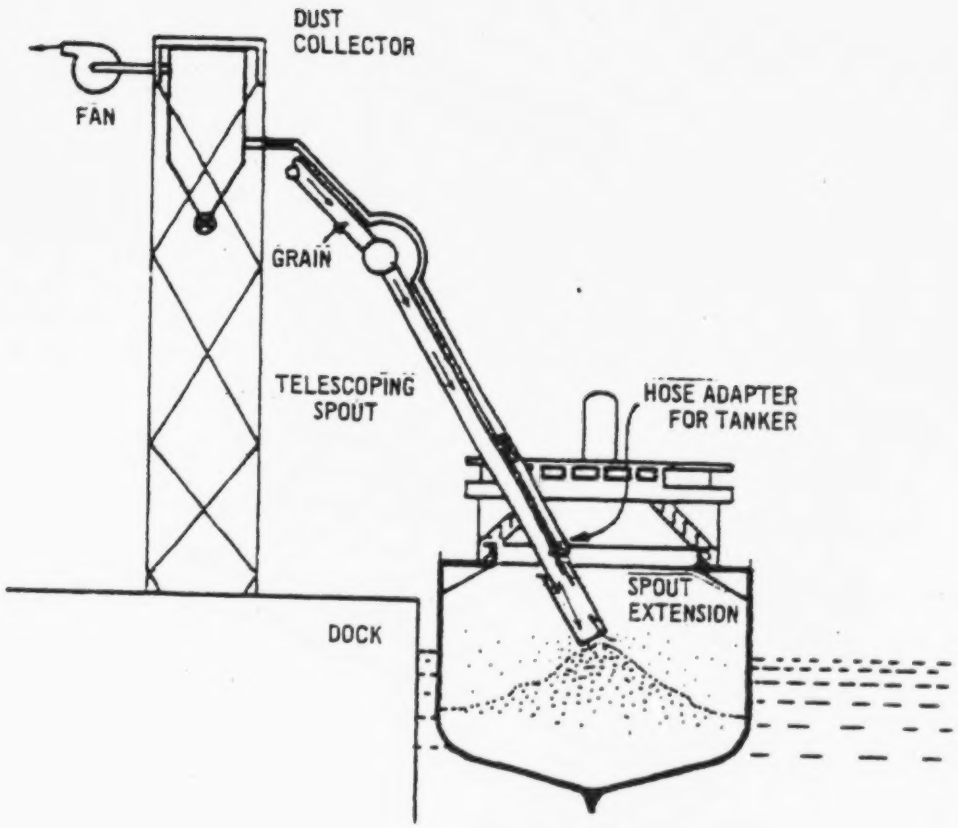


Figure 4-17. Barge or shiploading dust control system.

4.1.8 Ships

The major approaches used to control emissions from ship loading are discussed below:

The entire hold is covered with canvas or plastic except where the loading spout enters. Dust may be aspirated from beneath the cover to a cyclone or fabric filter, but in some cases the cover is used to make the hold a large settling chamber.[4,9]

In another approach, a telescoping loading spout is kept extended to the grain surface. Aspiration can be applied to the end of the spout and the dust collected in a fabric filter as shown in Figure 4-17. However, some facilities do not have an aspiration system and depend upon the pouring spout being kept just a few inches above the grain pile, thus reducing the free-fall and keeping emissions to a minimum. Any emissions escaping this system are not captured. Visible emissions of fugitive dust seldom exceed 20 percent opacity when either system is used and the dust is aspirated to the dust collection system.[2]

Finally, a choke or controlled type feeder (as discussed and shown in the truck loading section is used at most new modern loading terminals.[14,24] Visible emissions of fugitive dust seldom exceeded 10 percent opacity when this system was operating properly,[14] and during plant visits for the NSPS review. All modern or modified elevators visited during this review used only fabric filters as the control device on ship loading operations.

4.1.9 Potential New Control Technology

Some companies are experimenting and using additives such as oil, water, and steam as methods for reducing dust emissions. One company is using

water sprays on their ship loading facility. Water is applied at the rate of 0.2 percent using carefully calibrated pumps and nozzles in each pouring spout. The ship loading facility uses a standard telescoping pouring spout which depends upon keeping the free-fall distance between the spout discharge and grain pile to a minimum to help reduce dust generation. EPA in this review did not see the water system in operation, but local and State agency personnel report good results with the system.[15]

A couple of companies have been experimenting with and using a mineral oil which is sprayed on the grain as it is carried by a conveyor belt. The oil is applied by carefully controlled metering pumps and spray nozzles at the rate of about 200 ppm. EPA observed a demonstration of the oil system at a large inland grain terminal.[16] The results between the tests with grain and no controls versus using the oil spray were dramatic with nearly zero opacity for the oil test compared to 40-50 percent opacity for the uncontrolled test. Oil spraying is reportedly being used by another company at various points in their in-house processing of grains which are used internally.[5] Oil treatment has been approved for use on grains for animal usage, but has not been approved for shipment of grains overseas or grains for human consumption.

Oil treatment appears to have several advantages in that it appears that the grain may be re-handled without generating excess dust emissions. One company estimates conservatively that almost 40 percent of their energy bill could be reduced due to not operating emission control systems.[4] Also, maintenance and other operating costs would be reduced or eliminated. Furthermore, one of the most important aspects of this system would be the

potential for eliminating explosive situations, other safety and housekeeping problems (OSHA regulations), and the possible elimination of dust handling systems. However, some potential problems in the case of oil treatment to be resolved are possible rancidity of the grain with time, oil build-up on the process equipment with time, and the additional cost of treatment per bushel of grain compared to conventional dust control systems. Another potential dust suppression system being studied by one company is the use of steam.[18] The company has done some development work and has it in operation on a rail loading facility. They claim good results, but EPA did not see the process in operation during this review.

All the systems have the potential to suppress dust emissions and deter potential explosive problems, OSHA problems, reduce operating, maintenance, and energy costs, and recover the dust that is now discarded or sold at a loss.

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4. Trip Report: Louis-Dreyfus Corporation, Portland, Oregon, June 24, 1982.

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13. Trip Report: Cargill, inc., Burns Harbor, Indiana, September 8, 1982.

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19. Grain Dryer Compliance Test, South Dakota Department of Water and Natural Resources, January 6, 1983.

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24. "Controlling Dust for Barge and Ship Loading," Richard J. Nolan, R. S. Fling & Partners, Inc., Grain Dust Control Seminar by National Grain and Feed Association, St. Louis, Missouri, May 7-8, 1981.

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5. COMPLIANCE TEST RESULTS

Since August 3, 1978, when the NSPS were promulgated, six grain elevators have been newly constructed or had major modifications which made them subject to NSPS. Two of these plants had compliance tests conducted for particulate matter on some of the control devices. Visible emissions tests were conducted at one of the six plants. Two of the plants[3,4] are still undergoing modifications and compliance reports from two State control agencies have been received on two other plants.[5,6]

5.1 Particulate Emission Test Data

During this review, available emission test data were obtained for two grain elevator terminals from the State of Texas.[1,2] These data are summarized in Table 5-1. These data show that the fabric filter control devices easily met the NSPS requirements for particulate matter emissions. At one grain elevator, there were 36 different fabric filters, therefore, the State, with EPA approval, chose four fabric filters to be tested and these would be considered typical for all fabric filters to determine if the facility was in compliance. At the other grain elevator terminal, a new scale tower system that had to meet NSPS was source tested . Again, the results show the fabric filter control device easily met NSPS requirements for particulate emissions. Process information was taken during the compliance tests and shows that normal operating conditions were being observed during the tests.

5.2 Visible Emissions

Visible emission readings were taken for the compliance tests at plant B. The results show that the opacity readings from the control

devices were zero, thus, meeting NSPS requirements. Plant visits to several grain elevator terminals during this review did not reveal any apparent violations of the grain elevator visible emission NSPS (unofficial readings) requirements for all the processes required to meet the NSPS.

5.3 Other Atmospheric Emissions

There is not any known data of other atmospheric emissions from grain elevator terminals. Some elevators have dryers which are usually fired by gas. However, no data have been found on the amount of emissions from grain dryers on this source.

5.4 Water and Solid Waste Emissions

There are no known grain elevators that use wet scrubbers, however, one company reports using a grain washer. The water from this washer is captured and sprayed on vacant land on the property of the grain elevator.

At some grain elevators, the dust from the control devices (except ship loading) is captured and sent to a storage silo where the dust is sent to a landfill or sold. Most elevators return all dust to the process stream. The major reason for collecting and removing the dust, other than environmental considerations, is to reduce the potential for dust explosions.

TABLE 5-1. COMPLIANCE TEST DATA

Plant	Source	System	Emissions (a) gr/dscf	Emissions (a) g/dscm	Percent Opacity(b)	Reference
A	Scale tower	FF	0.0004	0.0009	0	1
B	Scale tower	FF	0.0051	0.0117	NT	2
B	Rail unloading	FF	0.0062	0.0142	NT	2
B	Transfer house	FF	0.0054	0.0126	NT	2
B	Silos	FF	0.0033	0.0076	NT	2

(a) EPA Method 5 for particulate matter: average of 3 tests.
NSPS = 0.0230 g/dscm (0.01 gr/dscf)

(b) EPA Method 9 for visible emissions.

CODE - FF = fabric filter
NT = not taken

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6. COST ANALYSIS

The purpose of this chapter is to present updated capital and annualized costs for the control systems used to achieve the NSPS. The model plant size, air flows, and control devices are shown in Table 6-1. The costs are presented for each of the affected facilities for the various capacities shown on Table 6-2. The cost-effectiveness of the control systems is also presented. All costs are in terms of August 1982 dollars. Actual industry costs are used where available.

The capital cost of a control system includes all the cost items necessary to design, purchase, and install the particular device or system. The capital cost includes the purchased costs of the major control device and auxiliaries such as pumps, fan, and instrumentation, the equipment installation cost including foundations, piping, electrical wiring, and erection; and the cost of engineering construction overhead, and contingencies.

The annualized cost of a control system is a measure of what it costs the company to own and operate the system. The annualized costs include direct operating costs such as labor, utilities, and maintenance; and capital related charges such as depreciation, interest, administrative overhead, property taxes, and insurance.

6.1 Updated Costs for the Affected Facilities

The NSPS for grain elevators cover particulate emissions and equipment standards for the dryers and marine legs. The updated costs, including capital costs, annualized costs, and the cost-effectiveness for each system

TABLE 6-1. PORT TERMINAL MODEL PLANT CONTROL DEVICES, AIR FLOWS, AND COSTS

Type Facility	Process	Percent Throughput	Control Device	Air Flow (cfm)	Capital Costs $/cfm	Operation and Maint. Costs $/cfm
Port terminal 80,000,000 bu/yr throughput.	Truck	20	FF	20,000	8.40	0.51
	Rail	45	FF	30,000	8.40	0.51
5,000,000 bu storage capacity	Barge	35	FF	40,000	8.40	0.51
	Grain	100	FF	240,000*	8.40	0.51
	Drying (3)	100	Vacuum screen	900,000**		
	Land	1	FF	30,000***		
	Ship	98	FF	60,000	8.40	0.51

* Based on information from questionnaires, a facility of this size would have control devices cleaning about 550,000 cfm of gases, therefore, subtracting the loading and unloading facility air flow the balance of air flows would be used for conveyor hoods, transfer points, silos, cleaning, weighing, etc. as the grain passes in and out of the terminal.

** 50-75 percent of air flow is recirculated depending on the type of dryer.

*** In most cases, the system used here will be the same system used for unloading.

TABLE 6-2. CAPITAL COSTS, ANNUALIZED COSTS, AND COST EFFECTIVENESS (cont)

Process	Emissions to Meet NSPS (T/yr)	Emission Reduction (Tons/yr)	Capital Cost ($)	Annual Cost ($/yr)	Cost $/ton
Receiving					
Truck	3.3	61.5	168,000	28,021	456
Rail	7.8	147.0	252,000	42,032	286
Barge	5.7	107.7	336,000	56,043	520
Handling	14.1	691.5	2,016,000	336,258	486
Shipping					
Land (2)	0.5	8.5	(Assume same unit as rail unloading)		
Ship (3)	53.5	837.5	3,504,000	725,050	866
Drying (1)	12.7	620.9	263,000	57,000	92

(1) Based on using air pollution control systems for 3-3500 bu/hr dryers and having to dry all grain handled to meet contract specifications.

(2) These emissions would probably be recovered from the truck or train unloading system as is done with most port facilities that ship by land. Therefore, in this model, these emissions were added to the rail loading system as it is very unlikely that only truck loading is done at a port terminal.

(3) Includes cost of control devices, choke type pouring spout, and heavy structural modifications to shiploading dock.

TABLE 6-2. CAPITAL COSTS, ANNUALIZED COSTS, AND COST EFFECTIVENESS

Process	Percent of Throughput	Particulate Emission Factors (lb/T)	Uncontrolled Emissions (T/yr)	Estimated Collection Effectiveness Before NSPS (%)	Emissions Before NSPS (T/yr)	Estimated Collection Efficiency for NSPS(%)
Receiving						
Truck	20	1.0	240	73	64.8	95
Rail	45	1.0	540	73	145.8	95
Barge	35	1.0	420	73	113.4	95
Handling	100	1.7	1,680	58	705.6	98
Shipping						
Land	1	1.0	12	25	9.0	94
Ship	98	1.0	1,188	25	891.0	94
Drying**	100	1.1	1,320	52	633.6	98

are shown in Table 6-2. These costs were updated to August 1982 dollars using the Chemical Engineering plant cost index and company and vendor data in 1982 dollars.[1,2,3,4,5] The original costs were presented in the NSPS support document and were calculated based on January 1976 dollars.[1] Table 6-2 also presents the emission reduction resulting from application of control techniques. These reductions are based upon the difference between the levels reported in the NSPS support document before NSPS proposal and NSPS.

6.1.1 Particulate Control

For each of the particulate control systems shown in Table 6-1, no credit was taken for any recovered grain dust even though most companies report selling the dust for $10-24 per ton.[7,8,9,10] For the model plant shown in Table 6-1, the dust recovered from the various control systems (except for the ship loading) would reduce the annual operating costs approximately 5 percent if the dust was sold at a minimum price of $10 per ton.

Actual capital costs were obtained from several companies and vendors for the control devices associated with the facilities subject to the NSPS. Most companies reported the total capital costs for all control systems and based on total air flows required for these facilities, a dollar per cubic feet per minute (cfm) relationship was developed (see Table 6-1). This relationship compared favorably with vendors' engineering estimates for similar control systems.[3,4,5] The capital costs shown for each affected facility in Table 6-2 are based on this single cost per cfm. The capital cost for material handling control systems may be less than

some of the other more elaborate control systems for the loading or unloading facilities, but the total costs are still representative of the actual total costs of control. Development of more specific capital costs for each affected facility would be difficult because the capital costs for these affected facilities depend greatly on site specific requirements.

The capital costs for the dryer system were developed from vendor information for some recent installations and reflects the difference in costs between a dryer that meets NSPS versus a dryer without a screen column control system.[3,5] The model plant includes three 3500 bu/hr dryers through which all of the grain processed would be passed. These systems are usually designed so that each dryer can be fed and discharged at 15,000-20,000 bu/hr. They are designed in this manner because most of the grain coming to port facilities has been dried once and usually all the grain needs is an additional 1 or 2 percent of drying to meet contract specifications compared to 5 to 6 percent at country elevators or inland terminals.

The cost effectiveness for each affected facility is shown on Table 6-2. The cost effectiveness results do not reflect any credit for grain dust sold. A separate cost-effectiveness for land loading facilities was not calculated because most land loading facilities use the same control system for loading and unloading as port terminals. Therefore, the emissions from loading were added to the rail unloading systems (rarely do port facilities load trucks) which is included in the cost-effectiveness for this affected facility.

One should note that the cost-effectiveness data shown on Table 6-2 are prepared as if the costs of removing the dust are solely due to the NSPS. Actually, much of the cost should be ascribed to minimizing explosions and improving worker exposure. Operators of grain elevators have been advised and are keenly aware that dust generation, if not controlled, can cause severe explosions. One of the major recommendations of the National Materials Advisory Board, investigating grain elevator explosions, was to advise all grain elevators to control dust generation and remove airborne dust from all grain processes.[6] Furthermore, it was recommended by the Academy that cost-effectiveness studies be conducted on the cost of adding dust removal and control systems versus the potential dollar loss if no action is taken.

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10. Questionnaire Response, United Grain Corporation, Vancouver, Washington, August 9, 1982.

7. ENFORCEMENT ASPECTS

EPA Regional Offices, States and local agencies, and companies subject to the NSPS were contacted to determine any problems with either enforcing or complying with the NSPS. Discussions with EPA offices and State and local agencies indicated that there are no major problems in enforcing the NSPS. The major concern in enforcing the NSPS comes mainly from the ship loading operations, because it is difficult to determine where to read opacities coming out of the hold of a ship. The hold opening may be 40 feet by 40 feet or more on large bulk carriers and it is sometimes difficult to position oneself correctly to read opacities. Also, wind currents may pick up dust that has settled on the grain in the ship's hold and combine these with the emissions from the loading operation.

Despite these problems with shiploading, good loading practices and well controlled and maintained equipment will keep emissions to a minimum. Also, an experienced opacity reader should be able to find a position that allows the reader to make sensible opacity readings even under somewhat difficult circumstances.

Weather conditions are a problem that can present a unique situation which is difficult to control. If loading is proceeding in an area where PM emissions will cause problems to the environment or surrounding area (for example a nearby residential area), tarps may have to be used to reduce this effect. However, tarps cannot be used during the "topping-off"

process and the enforcement agency will have to use powers of persuasion and common sense to be sure that the loading operations are being conducted by the loading operators as cautiously as possible under the circumstances to minimize PM emissions.

Company personnel contacted on plant visits during this review indicated that, except for ship loading, they have no problems complying with the NSPS. The companies also commented that they have not experienced any problems in interpreting the NSPS or degradation in terms of emissions or operations since the initial installation of the control systems.

Enforcement agencies have used reasonable judgment by choosing 4 or 5 key control systems (out of 20-40) when they have required compliance tests (especially for Method 5) and if these systems meet the NSPS, it is assumed the others are in compliance.

8. ANALYSIS OF POSSIBLE REVISION TO THE STANDARDS

The EPA Regional Offices, State and local agencies, and industry were contacted to determine the number and location of new or modified facilities subject to the NSPS. Available NSPS compliance test data and opinions of control agency and industrial personnel were solicited regarding all facets of the NSPS. As shown in Chapter 5, the limited amount of data subject to the NSPS indicate that all are in compliance with the NSPS. No new control technology has emerged since the inception of the NSPS. The only concern of control agency and industrial personnel was meeting the ship loading NSPS. No difficulties have been reported in terms of enforcing the NSPS, but there has been some confusion by some agencies on the modifications section of the NSPS.

This chapter will analyze possible revisions to the NSPS for each affected facility.

8.1 POSSIBLE REVISION TO NSPS

8.1.1 Truck Loading

No truck loading operations were viewed during plant visits because truck loading is more predominant at country elevators and inland terminals and no truck loading facilities were found that were subject to the NSPS. Because the costs are still expected to be reasonable and no difficulties in meeting the truck loading standard have been reported by control agency or industry personnel, there appears to be no need to revise the NSPS for truck loading.

8.1.2 Truck Unloading

Several truck unloading facilities were seen in operation during plant visits. All truck unloading station enclosures were open at each end so that a truck could be driven through the enclosure to where the truck's tailgate would be in the correct position over the receiving hopper. In the best truck unloading stations, doors on the opposite end of the enclosure from the truck's position would automatically close or be closed by the operator before the truck was raised and the grain dumped. All stations observed with closing doors at one end met the standard but those truck unloading stations open on both ends rarely met the NSPS and never met the NSPS if any wind was blowing. Two State agencies provided written inspection reports that stated that the NSPS truck unloading facility in their State met the NSPS.

One could totally enclose the truck unloading station. However, this would require considerable addition to the building to handle the trucks being raised, thus increasing the capital costs significantly. Also safety would be questioned because trucks have occasionally slipped the safety devices and fallen. In a total enclosure this could be dangerous and cause costly damage. Considering the small decrease in emissions for a total enclosure versus the enclosure with doors on one end, total enclosure does not appear cost-effective.

Because the costs are reasonable and no difficulties in meeting the standard have been reported by control agencies or industry personnel for those facilities using end door closures, there appears to be no justification for revising the NSPS for truck unloading.

8.1.3 Railcar Loading

No railcar loading operations were seen during plant visits. Most railcar loading occurs at inland terminals and no railcar facilities were found that were subject to the NSPS. Because the costs are still expected to be reasonable and no difficulties in meeting the standard have been reported by control agency or industry personnel, there appears to be no need to revise the NSPS for railcar loading.

8.1.4 Railcar Unloading

Several railcar unloading stations were observed during plant visits. All stations observed (uncertified Method 9 opacity readings) met the NSPS. One State sponsored Method 5 compliance test on the control device met the NSPS. Two State agencies provided written inspection reports that state that the NSPS railcar facility in their State met the NSPS. Most railcar unloading stations are large enclosures open on each end. Usually emissions are only generated at the beginning of dumping a car as the initial surge of grain hits the bottom of the hopper. Those emissions escaping the hopper control system usually fall out within the railcar unloading enclosure and rarely escape to the atmosphere.

One could require doors on the enclosure ends and that they be closed during the unloading operation; however, such enclosures would significantly slow operations. Most large terminals are designed to handle large quantities (bushels) of grain and the railcar unloading stations at those large terminals are designed to handle unit trains (100 cars or more) so that unit handling costs are kept to a minimum.

Besides the extra capital expense of installing the doors, the cost to the company of having to connect and disconnect railcars so that the doors could be closed would be significant and negate the efficiency of using unit trains.

Because the costs are reasonable and no difficulties in meeting the current standard have been reported by control agency or industry personnel, there appears to be no need to revise the NSPS for railcar unloading.

8.1.5 Barge or Ship Unloading

Barge unloading was observed in operation during plant visits and met NSPS levels. All the unloading facilities had equipment designed to meet the NSPS even though they were not required to meet the NSPS. Two State agencies reported that the NSPS barge unloading facility in their State met the NSPS. No official data were provided other than written inspection reports from on-site inspectors. Barges are unloaded by a marine leg which is essentially a bucket elevator that is placed on the grain which picks up the grain and transfers it to a conveyor system and to storage. The enclosed top half of the marine leg is connected by ductwork to a control device. The NSPS requires that the flow rate to exhaust the marine leg be a minimum of 40 ft^3 of air per bushel of grain unloaded. No ship unloading was observed because it is rare for a grain ship to be unloaded in the United States. However, the same technique would be used for ship unloading as is used in barge unloading.

Marine legs are the only unloading technique used in the United States at this time. There were some references noted in trade periodicals that some foreign ports may use pneumatic systems to unload grains, but no information could be found on this technique during this review.

Because the costs are reasonable and no difficulties have been reported in meeting the standard by control agency or industry personnel, there appears to be no need to revise the NSPS for barge or ship unloading.

8.1.6 Barge or Ship Loading

No barge loading facilities were found that were subject to the NSPS. Therefore, none were seen during plant visits as most barge loading occurs at inland waterway terminals. However, barge loading and ship loading have similar loading equipment and emission control systems (discussed next).

Several ship loadings were seen during plant visits. All the facilities visited met the NSPS (uncertified Method 9 opacity readings). Two State agencies reported that ship loading facilities in their State met the NSPS. No official readings were provided other than written inspection reports from on-site inspectors. Observations during plant visits showed that with a commitment to good loading practices and control techniques (discussed next), the ship loading facility can meet the NSPS.

There are essentially two types of loading spouts used in ship loading operations. Each requires a similar but somewhat different loading technique if PM emissions are to be kept to a minimum. One technique, used

mostly by older facilities, utilizes a standard telescoping metal pouring spout that is about 18 inches or more in diameter and 50-80 feet long. Using this type of pouring spout usually requires that the ship's hold be covered with a tarp or similar material and the pouring spout inserted between the edge of the ship's hold and the tarp. The tarp reduces the PM emissions that are generated when the grain drops from the pouring spout into the ship's hold. However, when the grain fills the hold to within the last 25 percent from the top, the tarp has to be removed so the operators can see to "top off" or be sure the hold is completely filled properly, the ship balanced, and the grain as level as possible. If the operators did not finish filling the uncovered hold carefully (described in the next paragraph) significant emissions can be discharged to the atmosphere.

In completing the filling of the ship's hold the pouring spout is extended to within a few inches of the grain surface. This reduces the free-fall distance through the ambient air and keeps emissions to a minimum. Also, this same loading technique can be used for the entire ship filling operation without using a tarp. Again, proper operator control is the key to controlling emissions and readjustment of the spout is necessary from time to time; unfortunately the loading personnel who operate this equipment are quite independent and may or may not follow procedures that keep emissions to a minimum.

The second technique for controlling ship loading emissions is the use of a choke feeder. This system also uses a telescoping pouring spout

but has a larger and more complicated filling spout which is usually larger in diameter than a conventional spout. The choke feeder itself is located inside the filling spout and is a cylindrical unit that has large holes in the sides but closed on the bottom. Thus, the grain comes down the spout and hits the choke feeder which fills up and then slowly runs out the holes in the sides. The choke feeder is surrounded by another cylindrical unit which allows an annular space between it and the choke feeder. This annular space is under a negative pressure and the emissions collected are removed by ductwork leading to a baghouse. Considerable emissions are captured at the pouring spout. However, even with this type of loading system and for the best results in reducing PM emissions, the operator must keep the end of the pouring spout as close to the pouring surface as possible to keep the grain free-fall to a minimum.

At this time there does not appear to be any alternative control techniques, thus, what is being used today is best control technology. There is some development work being done using water, steam, and vegetable oil which show promise of reducing dust emissions from grain handling. However, none of these processes are operating on full scale operations and have not been approved for grain shipments (those for human consumption) by governmental agencies.

Another problem voiced mainly by State and local control agencies is the difficulty in reading opacities during ship loading. The opening of a ship's hold on a bulk tanker may be 40 feet by 40 feet or more. In

addition, weather conditions can affect opacity readings considerably, especially wind currents. The wind can swirl the dust plume around varying the opacity greatly. Also, the wind can pick up the dust already settled on the poured grain and add it to the pouring emissions. Sometimes it is difficult to position oneself correctly to get the best possible opacity readings. Lastly, there is not a specific or uniform method of where (height above hold) one should read opacities as the PM emissions leave the hold.

Even though some control agencies and industry personnel have commented on the difficulty in meeting the ship loading NSPS, plant visits and observations show that the NSPS can be met with proper loading techniques and a well maintained control system, and all NSPS facilities are in compliance. Therefore, there appears to be no need to revise the NSPS for the barge or ship loading facility at this time, but these facilities should be thoroughly studied again during the next review if these concerns persist.

8.1.7 Grain Drying

There are two types of grain dryers used in the industry; a column dryer and a rack dryer. One column dryer was observed in operation during the plants visits, and no visible emissions were seen. Also, information on grain dryers provided by three State control agencies show this affected facility can meet the NSPS. The column dryer feeds grain from the top down through a vertical cylindrical perforated steel plate column that has holes no larger than 0.094 inch in diameter. The

hot gases come up the column through the grain and discharge the moisture laden gases out through the holes. The rack dryer is similar except that the grain passes through heated baffles through which hot gases are passed. The rack dryer uses a 50 mesh screen or finer to capture particulate emissions. Recently, another dryer introduced a rectangular mesh screen with openings 0.0486 inch by 0.5 inch. One State control agency recently conducted a Method 9 compliance test on this unit and determined that it met the NSPS for grain drying.

Because the costs are reasonable and best control technology is being used and no difficulties in meeting the standard have been reported by State agency or industry personnel, there appears to be no need to revise the NSPS for grain dryers.

8.1.8 Grain Handling

Grain handling covers all aspects of moving the grain to and from the grain elevator processes as required. Grain elevators use conveyor belts to move grain and elevator legs to lift the grain to the top of the storage silos or the top of the head house to be cleaned, screened, dried, weighed, and stored. Some new, modern elevators even use conveyor systems to lift the grain instead of elevator legs. Most modern elevators use completely enclosed conveyor belts and transfer systems. These are all ducted to baghouses. The cleaning, screening operations, elevator legs, and weigh hoppers are also enclosed and ducted to baghouses.

Observations made during plant visits, baghouse compliance tests at two facilities, and reports by inspectors from two other control agencies show that the grain handling facilities meet the NSPS.

Because the costs are reasonable and best control technology is being used and no difficulties in meeting the standard have been reported by control agency or industry personnel, there appears to be no reason to change the NSPS for grain handling facilities.

8.1.9 Control Devices

All NSPS facilities use baghouses as the control device to capture particulate matter. Observations during plant visits, compliance tests (see table in Chapter 5), and control agency reports indicate the control device is easily meeting the grain loading and opacity standard. Other types of control devices, such as scrubbers and electrostatic precipitators (ESP) are not normally used because of the water pollution problems from scrubbers and the potential for explosions with ESP's. Cyclones will not meet NSPS requirements. Because the costs are reasonable and baghouses are considered best control technology, and no difficulties in meeting the standard have been reported by control agency or industry personnel, there appears to be no reason to change the NSPS for control devices.

8.2 POSSIBLE REVISIONS TO MONITORING REQUIREMENTS

The NSPS does not contain any monitoring requirements for the various affected facilities. Requiring monitoring and record keeping for each affected facility could pose a heavy paperwork and cost burden on the plant because of the large number of control devices used (for example, 36 at one facility).

Most facilities reported that baghouses are checked daily for any pressure drop changes, visible emissions, and potential maintenance problems. This is to assure that the baghouse and attendant equipment are operating

properly. The facilities visited and those responding to our quesionnaire did not report any abnormal or unusual operating and maintenance problems with the control devices. Malfunctions occur rarely and no records are kept. If a malfunction occurs, the entire system is shut down immediately.

It should be emphasized that these facilities and their manager are acutely aware that grain dust causes explosions. Therefore, plant inspections revealed clean (housekeeping) plants with computerized systems to monitor plant operations. Newer facilities have interlocks so that if a malfunction occurs within that process, the whole system shuts down. In fact, in some larger facilities every bearing is connected to a heat sensor and a computer which prints out the bearing temperature every few minutes. If the temperature goes above a set point, an alarm sounds and the process affected shuts down automatically. Grain elevators now monitor dust emissions and mechanical operations quite carefully for safety reasons.

Because companies monitor themselves closely for safety and other reasons, there appears to be no reason to revise the NSPS and require monitoring.

8.3 EXTENSION TO OTHER SOURCES

The NSPS covers all significant emissions in grain elevators. There are very few, if any, fugitive sources that are not controlled in NSPS facilities. This again is mainly due to safety considerations. Therefore, there is presently no reason to revise the NSPS to include other sources as all appear to be covered under the present NSPS.

There have been concerns expressed by control agencies and enforcement personnel that the size cutoff for grain elevators mandated by Congress is allowing a large percentage of grain elevators not to be regulated by the NSPS. Therefore, it is recommended that Congreee should consider reducing the cutoff size for grain elevators when Congress discusses changes to the Clean Air Act.

8.4 EXTENSIONS TO OTHER EMISSIONS

The NSPS regulates only PM emissions from grain elevators. As all the functions in grain elevators are grain handling processes, no chemical changes are made in the product. Therefore, PM is the major pollutant. The only other types of pollutants will be small amounts of combustion products that can be emitted from the grain dryers. Dryers usually operate only about 3 months per year and burn natural or propane gas.

Because there are no emissions other than PM to be controlled, there is no reason to change the NSPS.